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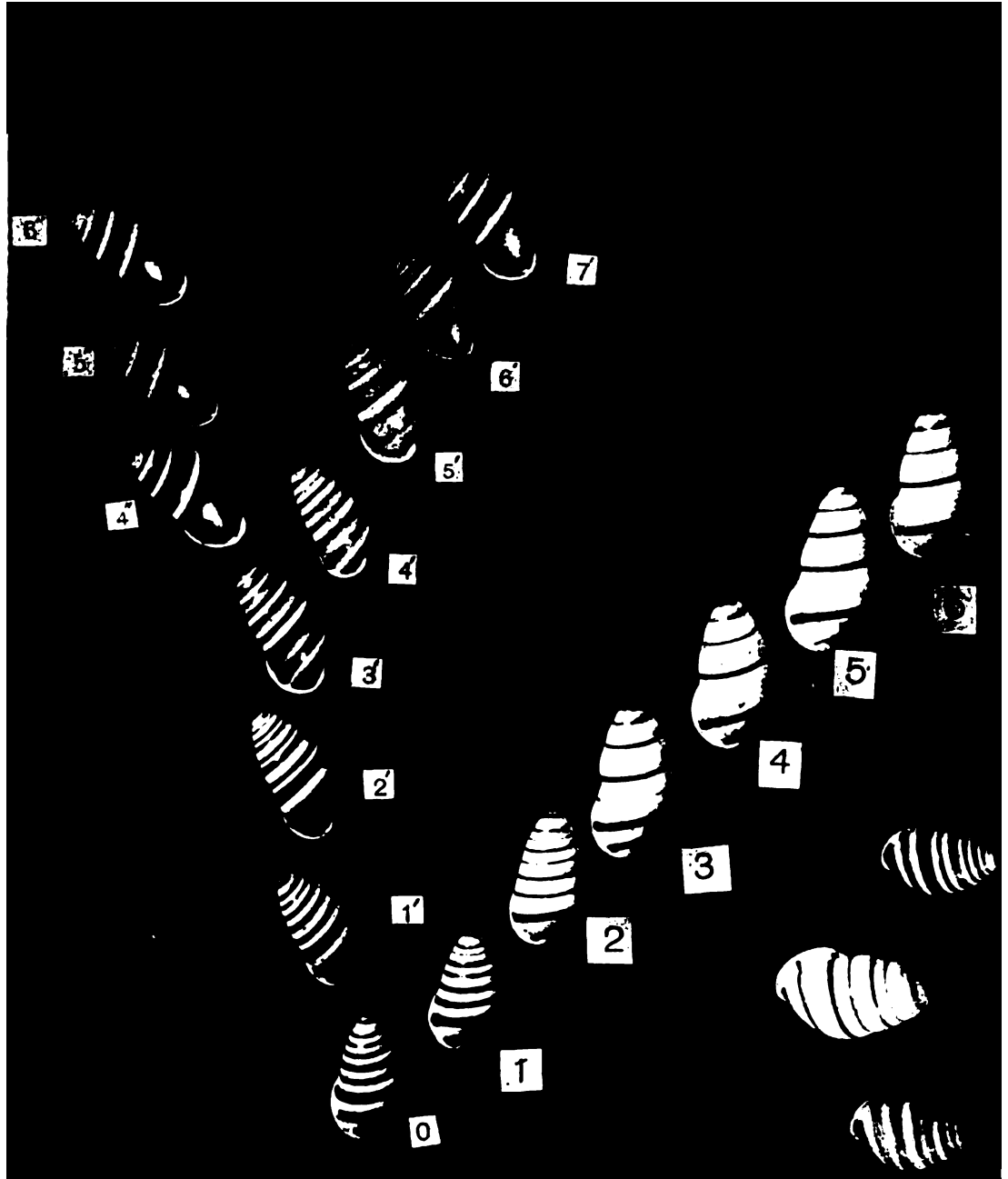

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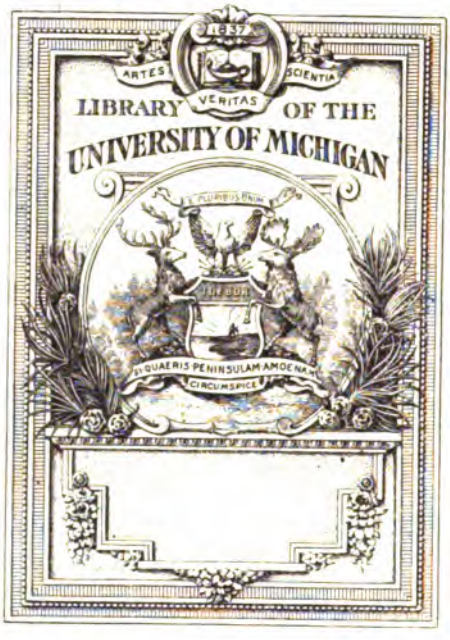

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TABLE OF CONTENTS.

VOLUME XV.

Papers read before the Academy and published in this volume. A list of those read and not published, or read only by title appears below.

TARLETON H. BEAN.

PAGE.

The Habits of the Young of the Pacific Salmon..... 182

H. P. CUSHING.

Notes on the Areal Geology of Glacier Bay, Alaska..... 24

On the Existence of Pre-Cambrian and Post-Ordovician Trap Dikes in the Adirondacks..... 248

BASHFORD DEAN.

Is Palæospondylus a Cyclostome?..... 100

On the Vertebral Column, Fins and Ventral Armoring of Dinichthys... 157

HARRISON G. DYAR.

Recent Notes on Bacteria..... 148

WARREN H. EVERETT.

Anatomy of the Ear of the Dog-Fish (*Galeus Canis*) Preliminary Paper 176

ARNOLD GRAF.

Adaptation of the Shell of *Crepidula fornicata* to the Shell of *Pecten Jacobæus*..... 67

BRADNEY B. GRIFFIN.

The History of the Achromatic Structures in the Maturation and Fertilization of Thalassema..... 163

ARTHUR HOLLICK.

Geological Notes, Long Island and Nantucket..... 3

JOHN DUER IRVING.

The Stratigraphical Relations of the Brown's Park Beds of Utah, 153 and 252

Digitized by Google

HAROLD JACOBY.

Suggestions as to the Determination of the Relative Masses of the two Components of the Double Star *Eta Cassiopeiæ* from Rutherford Photographic Measures..... 35

G. F. MATHEW.

On the Occurrence of Cirripedes in the Cambrian Rocks of North America 144
Faunas of the Paradoxides Beds in Eastern North America. No. 1..... 192

FREDERICK J. H. MERRILL.

Post-Pliocene Deposits of Sankaty Head..... 10
Notes on the Geology of Block Island..... 16

H. F. OSBORN.

A Memorial Tribute to Prof. Thomas H. Huxley..... 40

C. H. SMYTH, JR.

The Genetic Relations of Certain Minerals of Northern New York..... 260

JOHN J. STEVENSON.

Notes on the Geology of Indian Territory..... 50
The Cerillos Coal Fields, near Santa Fé, N. M..... 105

FRANCIS B. SUMNER.

The Varietal Tree of a Philippine Pulmonate..... 137

GILBERT VAN INGEN AND THEODORE G. WHITE.

An Account of the Summer's Work in Geology on Lake Champlain..... 19

T. G. WHITE.

The Faunas of the Upper Ordovician Strata at Trenton Falls, New York 71

Papers Read Before the Academy and either not published, or published elsewhere.

FRANZ BOAS.

Results of the Measurement of the School Children of Toronto..... 155

C. L. BRISTOL.

The Classification of Nephelis in the United States..... 66

J. McKEEN CATTELL.

A Method for Determining Photometric Differences by the Time of Reception..... 155

BASHFORD DEAN.

Instinct in Some of the Lower Vertebrates..... 126
Notes on Ancestral Sharks..... 40

Digitized by Google

R. E. DODGE.

Cretaceous and Tertiary Peneplains of Eastern Tennessee..... 143
The Physical Geography of New York City and Neighborhood (Public Lecture)..... 123

P. H. DUDLEY.

The Law of Deflection Sets Under Drop Tests in Different Sections of Steel Rails of Uniform Physical Properties Follows the Comparative Moments of Inertia of the Respective Sections..... 147

LIVINGSTON FARRAND.

Primitive Education..... 155

F. H. GIDDINGS.

A Plan for the Systematic Study of Tribally Organized Societies..... 154

ARNOLD GRAF.

The Problem of the Transmission of Acquired Characters (Abstract.)... 141
The Structure of the Nephridial in Clepsine (Abstract)..... 126

N. R. HARRINGTON.

Observations on the Lime Gland of the Earthworm (Abstract)..... 126

E. O. HOVEY.

The New Discoveries of Rare Minerals on Fort Washington Avenue and the New Speedway (Printed in the Bulletin of the Amer. Mus. Nat. Hist. XII. 341, Nov., 1895)..... 104

GEORGE S. HUNTINGTON.

Contributions on the Visceral Anatomy of *Myrmecaphaga jubata*, *Tamandua bivitata*, *Arctopithecus didactylus*, *Dadypus sexcinctus*, *Tatusia novemcincta*, *Manis longicaudata*. (Abstract)..... 98

HAROLD JACOBY.

The Reduction of Astro-Photographic Plates. (By title)..... 2
The Determination of Division Errors in Straight Scales. Outline and Historical Description of the Cape of Good Hope Observatory..... 63
On the Reduction of Astronomical Photographs taken near the Pole of the Heavens..... 124
On the Permanence of the Rutherfurd Photographs..... 147

A. A. JULIEN.

The condensed Gas Film in the Surface of Solid Bodies with relation to (1) Newton's series of the first order; (2) Sand flotation; (3) Sand in harmonic vibration..... 97

Digitized by Google

J. F. KEMP AND T. G. WHITE.

Additional Notes on the Petrography and Distribution of Trap Dikes in the Region of Lake Champlain. The paper will appear in a subsequent volume..... 105

J. F. KEMP.

The Cripple Creek Gold Mining District of Colorado. (Public lecture).. 127
The Great Quartz Vein at Lantern Hill, Mystic, Conn., and its Decomposition. (Abstract)..... 189
The Pre-Cambrian Topography of the Adirondacks. (Abstract)..... 189
Zinc and Lead Mines in Southwestern Virginia. (Abstract)..... 61

WALLACE GOOLD LEVISON.

Notes on Photographs of Geisler and Crooks radiant matter Tubes..... 156

L. MCI. LUQUER AND H. RIES.

An Area of Augen-gneiss, near Bedford, N. Y. Published in *The American Geologist*, October, 1896..... 191

L. MCI. LUQUER.

Notes on recent Accessions of Interesting Minerals..... 127

W. D. MATTHEW.

The Metamorphism of Triassic Coals by Diabase Dikes at Egypt, N. C... 105

A. M. MAYER.

A Heliostat with Small Mirrors, Giving a Beam of Intense Light and Forming an Image at its Focus..... 155
A New Polariscope..... 135

H. F. OSBORN.

A Mode of Evolution Requiring neither Natural Selection nor the Inheritance of Acquired Characters..... 148

C. A. POST.

Photographs of the Lunar Eclipse of September 2, 1895..... 63

M. I. PUPIN.

Experiments with X-rays..... 136
Magnetic Circuit..... 97
Röntgen's Discovery (Public Lecture)..... 146
Communication of come New Results of Experiments with the Röntgen Rays..... 147

J. K. REES.

Remarks on the Drawings made by Percival Sewell of the Markings on the Planet Mars..... 64

Digitized by Google

Some Problems About to Confront Astronomers of the Twentieth Century. (See *Science*, May 15, 1896.) 146
(1) The Harvard College Observatory Photographs of Star Clusters, Planets, Variable Stars and Stellar Spectra. (2) Prof. J. E. Keeler's Photographs of Planetary Spectra 147

HEINRICH RIES.

The Geology of Orange County, New York 70
A Visit to the Bauxite Mines of Georgia and Alabama 143
Notes of a Trip Through the Marble Quarries of Western New England and Eastern New York 188

W. L. ROBB.

Apparatus for Showing Vibrations of a Cord 135

C. H. SMYTH, JR.

The Origin of the Talc Deposits near Gouverneur, N. Y. (See *School of Mines Quarterly*, July, 1896) 154

O. S. STRONG.

The Use of Formalin in Injecting Media 99
A Case of Degeneration of the Optic Nerve in the Brain of the Skate, *Raja Erinacea* (by title) 148

C. C. TROWBRIDGE.

The Use of the Hair Hygrometer (by title, see these *Trans.* XVI. 2) 157

CORNELIUS VAN BRUNT.

The Natural Flora of Bronx Park (Public Lecture) 62

R. S. WOODWARD.

Results of Experiments on Metallic Spheres Falling in Water 2
Systems of Mechanical Units (abstract) 34

J. L. WORTMAN.

The Expedition of 1895 of the American Museum of Natural History ... 67

LIST OF PLATES.

Plate I. Geological Map of the Vicinity of Glacier Bay, Alaska.

Plate II. View of Sherman Falls, Kauya Hoora Gorge. Trenton Falls, N. Y.

Plate III. Fig. A. Undulations in layer (D 15) between lower and upper portion of the Great Fall, Kauya Hoora Gorge. Trenton Falls. Fig. B. Overlap structure of bedding of Trenton limestone, on east bank of West Canada Creek in Kauya Hoora Gorge. Trenton Falls.

Plate IV. Fig. A. Blue-black layer (D 11) with adjacent layers above Sherman Falls. Kauya Hoora Gorge. Trenton Falls. Fig. B. Example of

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Channel filling in D 22 north of railroad bridge, Kauya Hoora Gorge. Trenton Falls.

Plate V. Fig. A. Upper end of Kauya Hoora Gorge. Trenton Falls. Fig. B. *Palæospondylus Gunni.* Traquair $\times\frac{1}{10}$.

Plate VI. Varietal Tree of a Philippine Pulmonate, *Cochlostyla ovoidea.* To illustrate paper by F. B. Summer, p. 137.

Plate VII. Dinichthys Gouldi, Newberry ; $\times\frac{1}{4}$.

Plate VIII. Restorations of the Ventral Armoring of Coccosteids, Figs. 1, 2, 3.

Plate IX. Figures 1–6, illustrating the embryology of *Thalassema*, p. 163.

Plate X. Figures 7–12, illustrating the embryology of *Thalassema*, p. 163.

Plate XI. Figures 13–18, illustrating the embryology of *Thalessema*, p. 163.

Plate XII. Figures 1–2, illustrating the anatomy of the ear of the dog-fish, *Galeus canis*, p. 176.

Plate XIII. Figures 3–6, illustrating the anatomy of the ear of the dog-fish, *Galeus canis*, p. 176.

Plate XIV. Figures of Cirripedia, illustrating paper by G. F. Matthew, pp. 201–206.

Plate XV. Figures of Ostracoda and Agnostus, illustrating paper by G. F. Matthew, pp. 194–219.

Plate XVI. Figures of Agnostus, illustrating paper by G. F. Matthew, pp. 213–232.

Plate XVII. Figures of Agnostus and Microdiscus, illustrating paper by G. F. Matthew, pp. 233–242.

Plate XVIII. Geological Map of Brown's Park, Utah, illustrating paper by J. D. Irving, pp. 252–260.

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TRANSACTIONS

OF THE

NEW YORK ACADEMY OF SCIENCES.

REGULAR BUSINESS MEETING.

October 7th, 1895.

President REES in the chair, ten persons present.

The minutes of the last meeting (June 3, 1895) were read and approved.

Mr. R. E. Dodge, instructor in Geology in the Teachers' College, was nominated for resident membership, and referred to the Council.

There being no regular business, the Secretary made an informal report of the recent action by the Council in connection with the proposed reception next Spring, and in regard to the lecture course.

The various members of the Academy then gave informal reports upon the meeting of the American Association for the Advancement of Science at Springfield, Mass., in August, last; and also upon the proceedings of the affiliated scientific societies that met at the same time.

The Academy then adjourned.

J. F. KEMP,
Secretary.

STATED MEETING.

October 14th, 1895.

The ACADEMY met with PROFESSOR R. S. WOODWARD, Chairman of the Section of Astronomy and Physics in the chair.

Twenty-two persons present.

TRANSACTIONS N. Y. ACAD. SCI., Vol. XV., Sig. 1, January 13, 1896.

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The Secretary presented verbally the minutes of the preceding meeting.

There being no business, the Section of Astronomy and Physics immediately organized, and listened to the first paper of the evening by PROF. HAROLD JACOBY, entitled "The Reduction of Astro-Photographic Plates."

This paper was read by title, and was explained as being a discussion of the best formulæ for the reduction of the photographic plates selected by the International Committee for the Photographic Mapping of all the Heavens. It will be published as a bulletin of the Committee at Paris.

The second paper was read by R. S. WOODWARD: "Results of Experiments on Metallic Spheres Falling in Water." Prof. Woodward, after detailing various attempts to obtain data upon the law governing the motion of spheres in liquid, reported the results of a preliminary series of experiments, made at Columbia College last June. The experiments were performed by dropping spheres of steel, silver, aluminum and platinum in a tube of water sixteen feet long and one foot in diameter. The spheres varied in diameter from one inch to two inches. The interesting results of these preliminary tests are that all the spheres acquired a constant velocity inside of the first metre. Newton's law that resistance to motion is proportional to the square of velocity seemed to be verified. The times of falling were determined with a hyppchronoscope.

More elaborate experiments with the same apparatus will be made later. This paper was discussed by Prof. Jacoby and others.

W. HALLOCK reported upon some Summer work upon the action of the vocal chords in voice production, and described the photographs taken of the chords while in action, illustrative of their operation.

The Academy then adjourned.

WM. HALLOCK,
Secretary of Section.

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STATED MEETING.

October 21st, 1895.

No quorum being present the members adjourned.

J. F. KEMP, *Secretary.*

STATED MEETING.

October 28th, 1895.

The Academy met with Vice-President STEVENSON in the chair; twenty persons present.

The minutes of the last meeting were read and approved. The Secretary presented the nomination of James Marsland Lawton, Jr., for resident membership. The nomination was referred to the Council in the regular order.

The Geological Section then organized and listened to the following paper:

GEOLOGICAL NOTES.

LONG ISLAND AND NANTUCKET.

BY ARTHUR HOLLICK.

This paper was prepared from field notes taken during the years 1894–95. in connection with the Summer School of Geology of Columbia College.

Investigations with special objects in view were made during this time, which have been the subjects of previous communications.* After utilizing such material as was necessary for these, a number of disconnected notes remained, which are here brought together.

LONG ISLAND.

Marine Cretaceous. The development of our knowledge in regard to the extension of the Cretaceous formation eastward from

* Dislocations in Certain Portions of the Atlantic Coastal Plain Strata and Their Probable Causes. Trans. N. Y. Acad. Sci. XIV. (Oct. 15th, 1894) 8-20, figs. 1-5. etc.

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New Jersey has consisted of a series of discoveries, the significance of which could only be appreciated after they were linked together. The occurrence of strata belonging to the so-called non-marine Cretaceous (Amboy Clay Series of Newberry, Raritan Formation of Clark, Upper Potomac Formation of Ward) on Staten Island, Long Island and Martha's Vineyard was demonstrated some time ago, by the identification of numerous fossil leaves characteristic of the horizon, found at these localities. *

Evidence of any marine cretaceous, was, however, not so abundant, and on Long Island was confined to the alleged discovery of an *Exogyra*, in the moraine at Brooklyn, about sixty feet below the surface. †

During the summer and autumn of 1894 lithologic indications of marl strata were found on the north shore of Center Island at Oyster Bay, but a subsequent visit to the locality failed to verify them.

Shortly afterwards word was received from Prof. D. S. Martin, of the Brooklyn Institute, that a drift bowlder containing cretaceous molluscs, found on Long Island, was in the possession of the Institute. This, with all the facts in regard to it, was placed at my disposal. The material was found to consist of greensand marl, hardened by the oxidation of iron, and contained poorly preserved remains and casts of *Gryphæa vesicularis*, *Ostrea larva*, *Cucullæa* sp.?, *Serpula* sp.?, etc. It was discovered during the excavation of a reservoir inthe upper portion of the moraine at East New York (now the 26th ward of Brooklyn).

About the same time I was fortunate enough to find ferruginous concretions in the moraine at the end of Montauk Point, also containing fragmentary molluscs, too imperfect however for accurate determination. One specimen is apparently a *Gryphæa* and another is a coiled shell resembling a *Turritella*, but further than this no comparison would be advisable.

Meagre and unsatisfactory as these remains are, they nevertheless serve to indicate the former existence of marine cretaceous strata where no previous evidence of such had been found. Occurring as they do, as morainal material, we must necessarily infer that the outcrops from which they were eroded existed yet further to the north, and inasmuch as well-defined

* 1. Hollick, Arthur. Trans. N. Y. Acad. Sci. XI. (1892) 96-104; XII. (1892) 28-39; XII. (1893) 222-237; Bull. Torrey Bot. Club, XXI. (1894) 49-65, etc.
2. White, David, Am. Journ. Sci., XXXIX. (1890) 93-101.

† Jay, P. A. and Redfield, W. C. Minutes N. Y. Lyc. Nat. Hist. Dec. 19th, 1842; Jan. 9th, 1843; Abstr. Proc. 4th Session Assn. Am. Geol. and Nat. in Am. Journ. Sci. XLV. (1843) 156.

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marine cretaceous molluscs have been found at the southeast corner of Staten Island,* we should have to picture the former northern limit of the marl belt as curving northward so as to include the Narrows, thence diagonally across New York Bay almost, if not quite, to the East River, and thence into the basin of Long Island Sound and around the southeastern coast of New England. The evidence of its existence so far to the north in the vicinity of New York is somewhat of a surprise, and indicates that the clay belt here must have been very narrow if not entirely absent in places. Taken in connection with what we previously knew in regard to the occurrence of marine cretaceous strata eastward we should infer that the clay belt widened out in the Sound region and pinched out finally somewhere around the southeastern New England coast.

Yellow Gravel.—The extension of the Yellow Gravel formation from New Jersey through Staten Island, Long Island and eastward has always been a subject of interest to me, aside from any attempt to differentiate it into more than one horizon. Under this general name I am satisfied that the formation covered the entire coastal plain region, including Long Island, Martha's Vineyard and Nantucket, in pre-glacial times. The difficulty of identifying it at different parts of this region, and of differentiating it from other superficial gravels is often considerable, especially as it is so frequently involved with the gravels of the moraine. This matter was discussed by me in connection with explorations made on the north shore of Long Island,† where the characteristic silicified calcareous pebbles, containing palæozoic fossils, were found as far east as Lloyd's Neck. Subsequently I explored the gravels of the plain region, south of the moraine, with the result that similar fossils were found in abundance as far east as Mineola—probably as abundantly as in northern New Jersey. Continuing eastward they became more and more rare; the last finds being made in the vicinity of Brentwood. At Lake Ronkonkoma I failed to find any, and from thence further east the gravel was entirely quartzose and granitic, although manifestly representing the same formation.

Distribution of Cretaceous material in the moraine.—In the paper last quoted, attention was called to the well-known fact that there are two branches to the moraine on Long Island from Port Jefferson eastward. The northern or more recent one,

*The Palæontology of the Cretaceous Formation on Staten Island. Trans. N. Y. Acad. Sci. XI. (1892), 96-104.

†Some Further Notes on the Geology of the North Shore of Long Island. Trans. N. Y. Acad. Sci., XIII. (1894), 122-129.

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forms Orient Point, the southern or older one, Montauk Point. In the exploration of the northern branch I stated that I had failed to find the characteristic ferruginous concretions and sandstones, which are such prominent features in the moraine towards the western end of the Island, and which are of cretaceous origin. In explanation I ventured the conclusion that these must have been all carried forward in the first advance of the ice and should therefore be found in the Montauk Point branch. With this object in view a special trip was made and the region between Easthampton and Montauk Point was thoroughly examined.

At almost every exposure the characteristic material was found in greater or less abundance. Indications of fossils were rare however, and it was only at the extreme end of the Point that any were discovered. These consist of the molluscs already mentioned and of fragmentary plant remains. Amongst these latter is a specimen of *Tricalycites papyraceus* Newb., a species originally described from the cretaceous clays of Amboy, N. J., and also found on Lloyd's Neck. The verification of the conclusions previously arrived at was, therefore, highly satisfactory.

NANTUCKET.

General remarks.—The geology of this island has been so thoroughly described by Prof. N. S. Shaler* that any extended account on my part would be superfluous. It has been somewhat irreverently referred to by popular writers as "a sand heap in the Atlantic Ocean, bounded on the north by Cape Cod, on the east by Spain, on the south by the West Indies and on the west by Martha's Vineyard and Long Island." As a matter of fact it is an exceedingly isolated piece of land, when compared with any other portion of the eastern United States, being about twenty miles distant from Cape Cod, ten from Martha's Vineyard and seventy-five from Long Island. It is composed entirely of morainal débris, except for the broad beaches and long sand spits, which have been accumulated in more recent times. In shape it is rudely crescentic or somewhat resembling a bill hook. The greatest length—from Siasconsett to Tuckernuck Island—is about ten miles, and if the long, narrow sand spit known as Coatue Beach is disregarded, the average width at right angles to the greatest length is about two miles. The actual area is probably about eleven square miles.

The interest which especially attaches to the island is due to the fact that it occupies the extreme southeastern limit of glacial

*The Geology of Nantucket. Bull. no. 53, U. S. Geol. Survey.

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action in North America, thus presenting certain features not found elsewhere.

Character of the morainal material—To the student of glacial phenomena one of the most interesting features is the changes to be observed in the character of the morainal material in passing from place to place in an east or west direction. Thus on Staten Island it is largely of Triassic origin, but with Devonian and Silurian erratics and some crystallines. On Long Island the crystalline rocks of New York and New England are the predominent features, with cretaceous clays and an occasional trail of Triassic sandstone from some limited area, while palæozoic rocks are rare. On Martha's Vineyard clays, marls and sands of Cretaceous and Tertiary age, and New England crystallines, are practically all that are to be found. On Nantucket, in addition to quartzites and granites, we meet for the first time the igneous felsites and porphyries from eastern New England and occasional remains of Carboniferous rocks, presumably from the Rhode Island area.

In general structure the hills are strikingly like those of Long Island from Port Jefferson to Orient Point, that is to say the material of which they are composed is water worn, gravelly and sandy, with but little till and clay, the latter usually representing limi' l local deposits, although the indications are tha near to and elow sea level clay strata of considerable extent occur, upon which the sand and gravel deposits rest.

The only sections recently exposed and not previously described are to be seen along the cuts made for a new railroad across the hills from Nantucket City to Siasconsett. One of these cuts, about a mile from Nantucket City, at an elevation of sixty feet, is eight feet in depth. Here I found a lenticular mass of bluish-brown clay extending laterally for a distance of about one hundred and fifty feet, about three feet thick at the widest part, thinning out into a broken seam at each end and containing numerous small pebbles. It was underlain by stratified gravel and sand and overlain by unstratified surface sand. In other cuts visited nothing of importance was noted. The exposures were mostly of stratified sand and gravel with little or no clay or till and few bowlders.

Palæontology. The bluff which faces the ocean at Sankaty (spelled also Sankoty and Sancoti) Head is the locality which has received the largest share of attention from geologists, partly for the reason that the summit of the bluff is about eighty feet above tide level, the face affording the best exposure for studying the geological structure to be found anywhere on the island, and partly because fossiliferous beds of Post-Pliocene age occur there.

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These latter were made the subject of a communication by Messrs. E. Desor and E. C. Cabot as far back as 1849,* and an abstract of the same by Mr. A. S. Packard appeared in 1866,† while in 1875 a more extended account was published by Messrs. S. H. Scudder and A. E. Verrill.‡ In this latter paper more than fifty molluscs, besides several bryozoöns, crustaceans and echinoderms, are enumerated as having been found there. It is evident that there must have been a far better exposure of the strata when these accounts were written than exists at the present time. Thus the section as described by Desor and Cabot consisted of a bed of brown clay at the base, about twenty feet in thickness, over which were some sixty-five feet of stratified sands and gravels with peat and dune sand on the surface. Scudder also gives the same general description of the section, while in Shaler's report he notes the changes which have taken place in recent years, the formation of a wide beach and the masking of the base by a talus upon which a considerable growth of vegetation has taken hold, resulting in the complete obliteration of all trace of the clay.

At the time of my visit I searched for a long time before I could find any indications of a shell bed, but finally discovered an exposure about a quarter of a mile south of Sankaty Head lighthouse. It was so mixed up in the talus that its limits, especially in the lower part, were impossible to define, but I judged that the upper limit was about twenty feet above high water level and extended laterally only for a distance of some fifteen feet. The deposit had more the appearance of a pocket than a layer. Two hundred and sixty-one specimens, good, bad and indifferent, were collected, of which two hundred and five are *Ostrea*, *Arca* (*Scapharca*), *Serpula and Venus*, and of these a much larger number could have been gathered.

Following is a complete list, for verifications in which I am indebted to Professor R. P. Whitfield, of the American Museum of Natural History:

MOLLUSCA.

Buccinum undatum Linné. (Fragmentary.)
Ilyanassa obsoleta (Say.) Stimp.
Crepidula sp? (Fragmentary.)

* On the Tertiary and more recent deposits in the Island of Nantucket. Quart. Journ. Geol. Soc., London, V. (1849) Proc. p. 340; also referred to in Proc. Boston Soc. Nat. Hist., III. (1848) 79, and Am. Journ. Sci., XIV. (1852), 51.

† Mem. Boston Soc. Nat. Hist. I. (1866), 252.

‡ On the Post-Pliocene fossils of Sankoty Head, Nantucket Island; by A. E. Verrill; with a Note on the geology; by S. H. Scudder, Am. Journ. Sci., X. (1875), 364-375.

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Crucibulum striatum (Say.) H. & A. Ad.
Panopæa sp? (Fragmentary.)
Mesodesma Jauresi Joan.
Venus mercenaria Linné.
Venericardia borealis (Conr.) Carp.
Astarte undata Gould.
Arca (Scapharca) transversa Ad.
Modiola sp? (Fragmentary.)
Ostrea Virginiana (Lister.) Fav.

CRUSTACEA. ANNELIDA. BRYOZOA. PORIFERA.

Balanus eburneus Gould.
Balanus porcatus Costa. (Separate pieces only.)
Serpula (Hydroides) dianthus Ver. (Many specimens covered with a bryozoön—*Escharina Isabelliana* D'Orb?)
Cliona sulphurea (Desor.) Ver. (Represented by borings, especially in the shells of *Ostrea* and *Arca*.

Except in the case of *Panopæa* and *Mesodesma* this list adds nothing new to the previously published fauna of the shell bed, but continuous records of collections from the locality are of value and doubtless occasional new species will turn up whenever the material in the bed is carefully examined.

The most interesting and unexpected find was a fragment of silicified wood in the talus near the foot of the bluff, about a quarter of a mile east of the lighthouse. A superficial examination in the field led me to think that it must be a piece of palm wood. Subsequently sections were prepared for microscopic examination, but the tissues were found to be too imperfectly preserved for specific determination. They were submitted to Dr. C. C. Curtis, of Columbia College, and to Dr. F. H. Knowlton, of the United States Geological Survey. Dr. Curtis recognized the endogenous structure, without, however, deciding it to be palm wood. Dr. Knowlton considered it undoubtedly to represent a palm. I was unable to satisfy myself that it was either the same as or different from certain species of *Palmoxylon* * previously described. The only ones reported from the Eastern United States, however, were found in the

* *Palmoxylon* Schenk, Engl. Bot. Jahrb. III. (1882) 486. A generic term used to designate fossil palm wood.

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Pliocene(?) of Rapides Parish Louisiana.* These specimens also are described as being completely silicified and they apparently represent the same or nearly the same geological horizon as that at Sankaty Head. The age of our specimen is doubtless older than the Post-Pliocene sands in which it was found, however, and probably represents material which was eroded from Tertiary strata formerly existing at some point on or near to the present eastern coast of Massachusetts.

This conclusion seems to be a reasonable one so far as the geological age is concerned, as palms have not been definitely recognized below upper Cretaceous strata, and the only indication which we have of any palm representing the Cretaceous in eastern North America is the problematic one which I have called *Serenopsis* from Glen Cove, Long Island.†

This is of significance when taken in connection with the supposed existence of marine cretaceous strata at Marshfield, Mass.,‡ in which case the Tertiary strata, had they been present, would have normally occupied an area yet further to the eastward. It is of further significance as an indication of the probable direction of glacial movement in the region under consideration, and is confirmatory of Prof. Shaler's idea that nearly all the glacial waste of Nantucket was derived from a region east of "a meridional ine lying at least ten miles east of Boston."§

NOTE.—Since writing the above I have received the following paper from Dr. F. J. H. Merrill of the New York State Museum, with request that it be published in full:

POST-PLIOCENE DEPOSITS OF SANKATY HEAD.‖

BY FREDERICK J. H. MERRILL.

The geology of Nantucket is quite similar to that of Long Island, as it consists largely of stratified sands and gravels of

*Description of two species of Palmoxylon—one new—from Louisiana. F. H. Knowlton, Proc. U. S. Nat. Mus. XI. (1888), 89-91, Pl. XXX.

†1. Bull. Torrey Bot. Club, XX. (1893) 168, 169, pl. CXLIX.
2. *l. c.*, 334, 335, pl. CLXVI.

‡1. Hitchcock, Edward. Am. Journ. Sci. XXII. (1832), 1-70.
2. Shaler, N. S. Bull. Geol. Soc. Am. I. (1890), 443-452.

§The Geology of Nantucket, *l. c.*, p. 27.

‖The Editor of the Transactions has received this paper with the statement that it is the same one that was read October 25, 1886, under title "Notes on the Geology of Block Island and Nantucket." On p. 35 of Vol. VI. of the Transactions it is recorded as printed in the Annals, Vol. IV. This is erroneous, as it has not previously been sent in for publication. It is inserted at this point by order of the Council.

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the Post-Pliocene series, probably underlaid by clay and overlaid in many places unconformably by the surface drift.

The range of hills which marks the extreme southern limit of the drift is quite irregular, like that on Long Island, and averages about 90 ft. in height, likewise partly formed by the upheaval of stratified beds in folds parallel to the front of the ice sheet, which in this region had a direction a little south of east. Sankaty Head, the most easterly point of the range, has an altitude of about 105 ft., being the highest point on the island. It derives its geological importance from the section there exposed and the beds of Post-Pliocene fossils occurring near the foot of the bluff.

The locality was visited in 1849 by Cabot and Desor, who in a short article on the subject made some stratigraphical generalizations which were entirely imaginary. In 1875 it was visited by a party of the U. S. Fish Commission consisting of Prof. A. Hyatt, Mr. Sanderson Smith, Mr. C. H. Merriam and others, who made a collection of the fossils. Afterwards Mr. S. H. Scudder, of Cambridge, Mass., had an excavation made into the cliff, and Mr. Richard Rathbun made a collection of fossils. As the result of these researches we have the article published in the American Journal of Science, Vol. X., 3d Series, by Prof. A. Verrill. As my own observations differ somewhat from those of Mr. Scudder, I shall give them in detail, afterward comparing my conclusions with those of the investigator in question.

At a point about three hundred yards south of the lighthouse, which is near the summit of the eminence the following section is exposed:

1. Fine dark drifted sand	3 ft.	
2. Yellow sandy drift ferruginous at the bottom and containing pebbles	5 "	
3. Coarse gray stratified sand with particles of *greensand*	40 "	
4. Fine white clayey sand with ferruginous streaks and very minute particles of *greensand*	10 "	
5. Fragment bed	1 "	
6. Upper shell bed		8 in.
7. Clayey ferruginous sand		4 "
8. Serpula sand	1 "	3 "
9. Lower shell bed		9 "
10. Red sand with fragments of blue clay	1 "	
11. White sand of varying quality and size	4 "	
Concealed by turf and beach sand	24 "	
Total	90 ft.	

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Below stratum. 11, I was unable to examine the stratification on account of the tough grass which had overgrown the bottom of the cliff and resisted the means of excavation which I had at hand. Underneath the white sand, according to Mr. Scudder, there is about 4 ft. of coarse gravel and sand which in turn is underlaid by a brown sandy clay extending downward to the sea level. The lower shell bed is composed of reddish clayey sand like that the Gardiners' I., and contains chiefly *Venus mercenaria* and *Ostrea Virginiana*, the latter being especially abundant. Angular pebbles of 1½ in. or less diameter are numerous. The shells of *Mya*, *Venus* and *Ostrea* lie in all positions, the valves being often separated. The following is a list of species collected by the writer:

MOLLUSCA.

B. Ilyanassa obsoleta Stm.
B. Crepidula fornicata Lam.
B. " plana Say.
" convexa Say.
Odostomia trifida Gould.
Turbonilla interrupta Ad.
Mya arenaria Linn.
B. Ensatella Americana Ver.
Cumingia tellinoides Con.
B. Venus mercenaria Linn.
B. Scapharca transversa Ad.
Modiola hamatus Ver.
B. Ostrea Virginiana Lister.

NOTE.—B indicates that the species has also been found in the upper bed by Prof. Verrill or the writer.

Many of the oyster shells were honeycombed by the borings of *Cliona sulphurea* Ver.

The Serpula bed at the bottom consists of detached masses of *Serpula dianthus* Ver. closely packed together and intermixed with yellow sand and some clayey matter, while at the top the calcareous tubes are very much comminuted. Much of the Serpula is overgrown with the Polyzoan, Hippothoa variabilis Ver. According to Mr. Scudder, who superintended the excavations made in 1875 the bed in question was "almost wholly devoid of other fossils," but at the point where I examined it I found an abundance of shells of various species, viz.:

1. Ilyanassa obsoleta Stm.
2. Fusus scarlariformis Stm.

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3. Urosalpinx cinerea Stm.
4. Odostomia trifida Gould.
5. Turbonilla interrupta Ad.
6. Crepidula fornicata Lam.
7. " convexa Say.
8. Ensatella Americana Ver.
9. Venus mercenaria Linn.
10. Scapharca transversa Ad.
11. Modiola hamatus Ver.
12. Cumingia tellinoides Con.
13. Astarte castanea Say.
14. " quadrans Gould.

crustacea, etc.

P Balanus eburneus Gould.
Panopeus? Claws.

Over the Serpula bed is a layer of compact clayey sand containing *Ostrea Virginiana* and small specimens of *Arca pexata*. The upper shell bed consists of coarse beach sand with pebbles, slightly intermixed with clayey matter, and afforded the following shells:

Ilyanassa obsoleta Stm.
Crucibulum striatum Ad.
Crepidula fornicata Lam.
Ceronia arctata Ad.
Venus mercenaria Linn., very abundant.
Cyclocardia Novangliæ Morse.
Scapharca transversa Ad.
Astarte undata Gould.
" castanea Say.
Ostrea Virginiana Lister.

The uppermost fossiliferous stratum which I have called the fragment bed, but which Mr. Scudder has included with the upper shell bed, consists of white quartz sand and pebbles with a great abundance of comminuted shells. It contains a small proportion of clayey matter but differs very much from the upper shell bed, both by the condition of the fossils and by the entire absence of any ferruginous matter. In this layer I found the following species:

1. Ilyanassa obsoleta. Stm.
2. Lunatia heros Ad.
3. Skenea planorbis.
4. Margarita obscura Gould, fragments.
5. Rissoa aculea. Stm.

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6. Cæcum pulchellum. Stm.
7. Mactra solidissima. Chem.
8. Cyclocardia Novangliæ. Morse.
9. Modiola modiolus. Turton.
10. Astarte quadrans. Gould.
11. Balanus porcatus, very numerous fragments.

On the surface of the bank, in addition to species already enumerated, I collected two specimens of *Crenella glandula* Ad. As this shell is mentioned by Prof. Verrill as occurring in the lower bed, it is probable that the specimens in question belonged to that stratum.

Layers 3 and 4 are homologous with the stratified sand which forms the bluffs of the east and north shores and probably composes the whole island. The greensand is probably a constituent of the whole deposit, as it occurs everywhere in the bluffs within two miles of Sankaty Head and also at the town of Nantucket.

In Macy's History of Nantucket it is stated that shells have frequently been found in digging wells on the island. Prof. Verrill in discussing the probable origin of these beds states that the character of the fossils indicate a reduction in the temperature of the water of about 15° between the deposition of the lower and upper beds. He assumes that the lower and Serpula beds were formed in some shallow bay protected from the outer waters by a terrestrial barrier which was eventually removed and the cold outer waters flowing in, the Atlantic surf filled the bay with beach sand and broken shells.

From my own study of the deposit in question, I am inclined to differ with Prof. Verrill to some extent, and I do so with less reluctance inasmuch as he has not examined the locality himself.

The appearance and character of the different beds give strong indications that they are largely composed of transported material, and are the work, to a certain extent, of swift currents. The sand of the lower shell bed is clayey and ferruginous, and contains pebbles ranging up to 1½ inches in diameter. The shells, moreover, of *Ostrea*, *Venus* and *Mya* lie in all positions, the valves being often separated. This state of affairs is difficult to reconcile with Prof. Verrill's generalization. If the clayey ferruginous sand were the bottom of a sheltered bay, we have no means of accounting for the pebbles or the condition of the shells. If, on the other hand, it were a deposit subject to the action of waves, the clayey matter would have been washed from the sand. Apparently the conditions were such that the peb-

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bles, sand and clay were transported with the shells and deposited in their present resting place.

The serpula bed also presents some marked characteristics, the first of which is that all the tubes are free and completely separated from any attachment they may have had previous to their deposition. It cannot be advanced that they may never have been attached, for the habit of the Serpula is well known. The surface of the bed moreover consists of a layer of pulverized Serpula such as might be produced by the action of waves in shallow water, were not the intermixture of clayey sand with the Serpula conclusive evidence that no such action took place at this point while the deposit was being formed. Moreover there occur in the bed angular fragments of rock, such as are only produced by glacial action. If to account for these we assume that they have been dropped from floating ice at this point, we should expect to find an appreciable quantity of drift mingled with the Serpula, but we do not, as the small amount of clayey matter intimately mingled with the tubes could not have been introduced in this way. We must therefore conclude that this is also transported material from deposits formed, perhaps, only a short time previous. The shells of *Venus mercenaria*, moreover, appear to have been subjected to considerable friction from their smooth convex surface.

In the upper shell bed we have again a repetition of this evidence. Mr. Rathbun's observations, however, are not corroborated by the section exposed at the time of my visit. He states that the upper bed consists chiefly of broken shells without any ferruginous matter. While this is true of the fragment bed it does not apply to the fossiliferous stratum immediately overlying the Serpula bed, which is quite similar to the lower shell bed, but differs in its fossils, as already stated.

The fragment bed, which crowns the shell-bearing strata, offers a striking resemblance to unsolidified coquina, as Mr. Scudder has very justly remarked. It, however, differs from it in the fact that it contains much fine clayey matter, and hence, as a whole, cannot have been the immediate result of surf action.

The assumption that these beds consist chiefly of transported material is supported by the fact of the occurrence of glauconite in the stratified sands above and below the shell beds. This is well known to be a deep-water deposit and to occur out of reach of the land wash. Its presence in the deposits under consideration must, therefore, be due to the erosion of older beds and the mingling of their débris with fine sand which was brought to this region and deposited by currents probably originating from the first melting of the ice sheet. Again, at a point a few

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hundred yards north of the lighthouse, the upper stratified sands contain minute fragments of shells here also, showing the work of a transporting agency.

In conclusion, therefore, we may infer that the stratified beds which mainly compose Nantucket are formed of the *débris* of older beds possibly mingled with the worked-over drift of the early Quaternary. We may also infer that Prof. Verrill's deductions from the characteristics of the fossils enumerated, although they may be true of the original deposits, cannot be accepted as holding good for the beds as they occur at Sankaty Head.

NOTES ON THE GEOLOGY OF BLOCK ISLAND.

By Frederick J. H. Merrill.

This island, which is about 15 miles northeast of Montauk Point, is the eastward continuation of the deposits which occur on Long Island and forms a link in the broken chain of hills which marks the former southern extension of the continental glacier along the coast of New England. It is nine miles long and five miles broad in the widest part, and is noticeable from a distance on account of its high elevation, a large portion of the island being about 125 feet above the sea, Beacon Hill, the highest point, having an altitude of 210 feet. As at Gardiner's I., and elsewhere, the stratified beds are upheaved in parallel folds which trend from east to west and the general surface conforms to these elevations, but the undulating surface of Montauk Point is here presented on a larger scale, the minor inequalities of the surface bearing no visible relation to the disturbance of the underlying strata.

As shown by the map, the island is divided into two principal areas of elevation by Great or Salt Pond, which contains about 1000 acres and is somewhat more than seventy feet deep. This body of water was formerly a bay connected with the ocean on the northwest, but at present it is separated from the sea on either side by low and narrow necks of sand, beach and salt marsh. The northern area of elevation presents on the east an extensive section in the bluffs near Clay Head, which extend for a mile and one-half from north to south and have a maximum altitude of about one hundred feet. The formation here consists of stratified sand, gravel and dark lignitic clay raised up in anticlinals of 15° to 20° slope and overlaid by a thin stratum of surface drift or till. The lignitic clay which occurs through-

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out the island, evidently consists of transported material, from its heterogeneous composition, lignite sand, clay and pebbles being in places mingled together. The following section taken about a quarter of a mile south of Clay Head will show the general character of the formation:

Surface loam and drift	3 ft.
Blue clay	6 "
Stratified sand	15 "
Cobble-stone bed	4 "
Stratified bluish clay and sand	12 "
Ferruginous sandstone, soft	3 "
Whitish sand	4 "
Blue sandy clay	10 "
To the beach	57 "

At this point the three lowest beds are disturbed and faulted as shown in the following sketch.

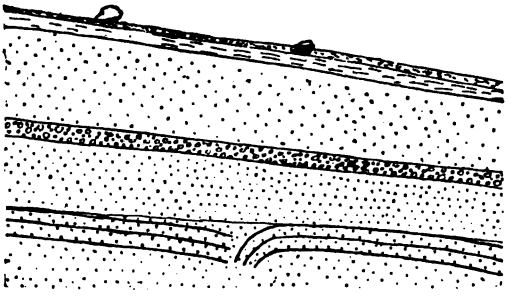

FIG. 1.

This formation shows that there were two advances of the ice sheet during the deposition of these strata, the first producing the disturbance shown in the lower part of the section when only those beds had been formed and the second producing the low but extensive anticlinal, in the north slope of which this point is situated.

Half a mile south, stratified sand, kaolin and white clay rise up through the lowest strata in an abrupt fold, the top of which has a curve of about thirty feet radius. This deposit in char-

TRANSACTIONS N. Y. ACAD. SCI., Vol. XV., Sig. 2, January 13, 1896.

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acter and position is entirely analogous to that at Glen Cove, L. I.

South of Great Pond is the larger and more elevated portion of the island. It is quite similar in structure and material to the northern part, already described. The lignitic clay, however, forms a more important feature in the formation and in the bluffs at the southeastern extremity attains its greatest development. From the breakwater southward and westward very extensive sections are displayed. Here again the stratified beds are upheaved, the axes of the folds having the same northeasterly trend. About 200 yards south of the breakwater the banks are about 30 feet high and consist of surface drift, finely laminated sand and lignitic clay. The latter varies from four to six feet in thickness and in many places is mingled with sand. The lignite is in quite small pieces and has nodules of pyrites associated with it. A section taken about one-fourth mile east of the south light was as follows:

Dark sandy clay with pebbles	10	ft.
Fine gray sand	2	"
Dark clay with pebbles and thin layers of sand	10	"
Ferruginous sand	8	"
Dark blue sand clay	1	"
Fine compact yellowish sand	1	"
Dark blue plastic clay	½	"
Yellow stratified gravel with cobble stones	20	"
To the beach	52½	"

At the south light house the cliffs are about 152 feet high and consist chiefly of dark stratified sandy clay, sand and gravel, which have been eroded into deep gullies separated by projecting ridges and pinnacles which present a most picturesque aspect.

West of the lighthouse the dark clays become less prominent and the cliffs are chiefly composed of stratified sand and gravel. The surface drift of the island nowhere attains any great thickness but contains many large boulders.

A study of these deposits reveals the fact that Block Island consists of Post-pliocene stratified beds underlaid by white clays and sands which may be of Cretaceous age. These strata at intervals during the deposition of the former have been subjected to glacial action which has folded and contorted them, and finally in the Champlain period the ice has dropped upon their surface whatever boulders or *débris* were imbedded in its

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mass. The lignitic clay is evidently composed of transported material from some Cretaceous or Tertiary bed to the northward.

Mr. Hollick's paper was discussed by Prof. W. M. Davis.

The second paper of the evening was the following:

AN ACCOUNT OF THE SUMMER'S WORK IN GEOLOGY ON LAKE CHAMPLAIN.

By Gilbert van Ingen and Theodore G. White.

During four weeks of June and July, 1895, the writers were engaged in an examination of the Ordovician rocks of the Champlain Valley. A few localities on the western side of Lake Champlain had already been examined by persons connected with the Department of Geology of Columbia College. These localities, four in number, namely Port Henry, Westport, Essex and Willsboro' were not again visited this year. During the trip all the important localities on both sides of the lake were examined, with the exception of those noted above.

The object of the work was the accumulation of material, primarily, for Mr. White's doctorate thesis on the Trenton faunas of the Lake Champlain region, and, secondly, for a study of the lower Ordovician faunas of the same region by Mr. van Ingen.

The system employed in recording field notes was that developed by Prof. Henry S. Williams, during his study of the Devonian formations of central New York. The town which is the temporary headquarters for field work of the vicinity is assigned a definite number as 108=Chazy, Clinton County. During the progress of the work in that vicinity every exposure or continuous section is assigned a letter of the alphabet, whether the section be along a shore, in the bed of a stream, a railroad cutting or a quarry. The geologically lowest layer in that section is sought and numbered 1; each superadjacent layer being numbered in series. The only field label then required with the collection from each layer is a small piece of paper with, *e. g.*, the symbol 108, F. 16. Reference to the field notes shows this layer to be a heavy black limestone, with conchoidal fracture, containing Maclurea in its upper portion, exposed in the bed of Little Chazy River at Chazy, Clinton County, N. Y.

At every locality the sections were carefully examined, each separate layer carefully measured, and as many fossils obtained from it as was possible without too great an expenditure of time.

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The collections sent in amount to 4500 pounds, which amount is about equally divided between the Upper and Lower Ordovician.

The first stop was made at Larrabee Point, Vt., at the southern end of the lake proper, at which point was found the best Trenton section seen along the lake. The rocks are exposed in a quarry and along the shore, dipping slightly to the north and northwest. The Black River limestone is well seen in the quarry near the sawmill south of the Lake House. At the top of the quarry are beds of impure shaly limestone containing a great abundance of *Parastrophia hemiplicata*, *Hall*. This brachiopod ranges through about six feet of strata and serves to mark this particular horizon all along the lake. It also serves as a means of recognizing the transition from the Black River limestone to the overlying Trenton limestone. These Parastrophia shales are exposed also on the shore, where they are overlaid by thin layers of the Trenton limestone. This limestone then extends along the shore in a northerly direction past the Lake House until it finally runs under the water, and is followed further north by the Utica shale; the transition between the two not being visible.

Shoreham, six miles east of Larrabee Point, was visited in hopes of finding deeper water sediments and consequent changes in the faunæ. Fine black shales seemed to be more abundant, but the rocks have undergone a considerable amount of metamorphism, and slaty cleavage has destroyed all but mere traces of fossils.

Ticonderoga, on the western shore of the lake, is surrounded by Calciferous rocks containing few fossils. Toward Crown Point, however, the Lower and Middle Chazy begin to come in, and some fossils may be obtained. On Crown Point, in the vicinity of Wilkerson's Ferry, were obtained fine specimens of *Maclurea magna*, in many of which the test remains intact, having separated freely from the matrix.

Fort Cassin was reached from Vergennes, Vt. At the former place a good collection of trilobites was obtained from siliceous limestone beds lying between the famous Fort Cassin and the *Calaurops* beds of Whitfield.

At Burlington a day was spent in examining the collections at the University of Vermont, through the courtesy of Prof. G. H. Perkins, and in visiting the red sandrock quarries south of the city. In these quarries there is an interesting trap dike described by J. F. Kemp in the paper on "The Trap Dikes of the Lake Champlain Region." Since Prof. Kemp's visit a considerable amount of rock has been removed from the quarry face,

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affording a section of the dike several feet east of that figured by Kemp. The fissure appears to have split so that now we see a double dike made up in section of two wedges, the lower of which is inverted.

Port Kent and Ausable Chasm were next visited. Back of Port Kent is an extensive plateau made up of thick deposits of sand and gravel. Underlying this terrace formation is the Potsdam sandstone. This is in layers varying in thickness from one to several feet, lying nearly horizontal It is a hard, compact quartzite, well resisting weathering except along the deposition planes. It is everywhere much traversed by vertical joint planes. Thus the loose bedding and the vertical jointing enable the stream to easily undermine the high banks. The larger part of the erosion is probably of this kind; there being apparently a small amount of abrasion. A few faults cross the chasm causing deep fissures in the opposite walls. The stream seems often to follow the line of a fault and then to turn abruptly aside, following the course of one of the joint systems.

At Plattsburgh the writers were joined by Professor H. P. Cushing, of Cleveland, Ohio, who very kindly devoted several days to pointing out the best localities in the vicinity of Plattsburgh and Chazy. At Bluff Point and along the shore south of Plattsburgh good sections of the Chazy rocks were examined and good collections of fossils obtained. Of special interest is the discovery of Foraminiferal shells in microsections of Calciferous limestone from south of Plattsburgh. The minute shells resemble somewhat in general shape those of the genus *Limacina* among the Pteropods. Crab Island, off Bluff Point, is an excellent collecting ground for Trenton fossils. The island has probably received its name from the numerous specimens of trilobites of the genus *Asaphus* which may be found in the loose blocks on the shore, which fossils are generally believed to be crabs by the natives.

Beekmantown, four miles north of Plattsburgh, is where the beautiful specimens of *Ophileta complanata* were collected by Prof. Seely, and which were described by Prof. Whitfield in Bull. Amer. Mus. Nat. Hist. II., 48; Pl. VII. These gastropod shells occur in vast numbers in a calcareous sandstone that outcrops in a low ledge one hundred feet wide, extending for some distance through the fields.

Cumberland Head, a few miles northeast of Plattsburgh, furnishes many outcrops of a black, shaly limestone. It contains a trilobitic fauna not found at any other point along the lake. The contained species are not forms that have been hitherto noted in New York, but resemble certain ones described by Billings from the Quebec group of Newfoundland.

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Chazy is the classic locality for the rocks of the Chazy group. The village is built upon them, and outcrops containing characteristic fossils are to be found in almost every yard. The quarries in the village and southeast of it, and Little Chazy River, afford good sections. The best section of the Black River limestone was seen there. The section shows that this formation may be split up into a number of zones, each characterized by its own peculiar faunula. From below upwards the horizons are marked; the lowest by a *Leperditia*, next a *Strophomena*, then follow *Stromatocerium* and *Columnaria*, *Maclurea* and *Parastrophia*. These horizons hold good for the Black River of that region. The *Maclurea* zone at the top of the Black River limestone is a most interesting find. Heretofore the large *Maclurea* has been known as characteristic of the middle Chazy beds only. At Chazy may be seen a zone six feet thick, at the top of the Black River, full of *Maclureas*. The species differs a little from the *Maclurea magna* as found on Crown Point. It is generally larger, but with a more impressed spire and with revolving lines on the sides and lower parts of the whorls.

Isle La Motte is across Northwest Bay from Chazy Landing. Some good fossils were obtained there from the Chazy, Trenton and Utica. At Fisk's Quarry handsome specimens of *Stromatocerium* were seen in the Middle Chazy. Further southward, at Fleury's Quarry, was seen a fine example of differential erosion along a joint plane. The Lower Chazy limestone is there made up of thin alternating layers of pure and impure limestone. The pure limestone weathers more quickly, leaving the impure bands standing out in relief and exhibiting well the feature of cross bedding. Many trilobite remains were obtained in this quarry. On the eastern side of the island were found some good graptolites in Utica shale. The shale dipping to the east is exposed for a mile along the shore. The dip then quickly changes to westerly, and soon the shale is seen to have been dragged along the western side of a fault, with the Trenton limestone on the eastern side. Further northward this Trenton affords characteristic fossils.

Highgate Springs, on Missiquoi Bay, was next visited. There the Cambrian section was gone over, but few fossils were found. Back of the Franklin House is a series of parallel ridges. Those of Ordovician age yielded some satisfactory results. All beds from the Calciferous to the Upper Trenton are exposed on the two sides of a north and south anticline. Standing on the Calciferous sandstone which forms the crest of the anticline, the various beds from lowest to highest dip away on either side. The harder layers form prominent ridges in the fields. To the

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south the ridges are seen to curve around in a semicircle, those of the eastern side proving to be continuous with those of the western side. It is a very pretty example of a tilted anticlinal fold; the slant in this case being toward the south. Here also, at the most northerly point examined, was found the *Parastrophia* horizon, as well marked as at Larrabee Point, seventy-eight miles to the southward. The Chazy also yielded some fossils.

Basin Harbor, near Vergennes, was the last locality examined. The Chazy is there finely developed. Good trilobites were obtained, the limestone being full of the minute young of *Asaphus*. Just south of Basin Harbor is Button Bay Island. This small island, covering about one acre, is entirely of Black River limestone. At the lower part of the section is a thin band of limestone containing myriads of *Leperditias* in perfect preservation. Near the top is a two-foot band, sharply defined above and below, and made up entirely of corals of the genera *Stromatocerium* and *Columnaria*. It is a most striking example of coral reef formation. Just eastward of Button Bay Island is a small island of Trenton limestone, from which the last collections were made.

It is expected that the results to be obtained from the work will be of considerable importance in the field of stratigraphic palæontology, for the region is a rich one and very little work has been done on the New York Ordovician since the publication of Hall's first volume of the Palæontology of New York in 1847. Accordingly careful work in which the various elements of each fauna are dissected out and fixed horizons established for a particular region cannot yield other than results of value.

The paper was discussed by J. F. Kemp.

The Academy then adjourned.

J. F. KEMP,
Secretary.

The following paper was read by title April 8, 1895, but was withheld for revision by its author. The title announced on p. 185 of Vol. XIV. of the Transactions is "Petrographical Notes on Rocks from Alaska."

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NOTES ON THE AREAL GEOLOGY OF GLACIER BAY, ALASKA.

H. P. CUSHING.

CONTENTS.

PAGE.
Introduction .....
General Geology .....
The Argillites .....
The Glacier Bay Limestone .....
The Quartz-diorite .....
Diorite .....
Crystalline Schists .....
Dikes .....
Comparison with other Alaskan Sections .....
Petrographical Notes .....
The Quartz-diorite .....
The Schists .....
The Dikes .....
Plate I. at close of Volume.

INTRODUCTION.

In the year 1890 a party under the leadership of Dr. H. F. Reid explored and mapped a considerable portion of the basin of the Muir glacier in southern Alaska. The writer was a member of the party and reported briefly to Dr. Reid on the areal geology of the district.*

In 1892 Dr. Reid returned to Glacier Bay and extended his work over a much greater area, exploring and mapping for the first time the shores of the upper part of Glacier Bay, an undertaking of the most laborious character.

From these newly explored shores Dr. Reid gathered rock samples whenever practicable, upon which he has requested a report. These specimens prove with a singe exception, to represent rocks similar in all respects to those already described from the vicinity by Dr. Geo. H. Williams and the writer. It has seemed, however, that a brief review of the whole matter, with such comparisons as can be made with sections reported elsewhere from southern Alaska, may not be wholly devoid of value.

GENERAL GEOLOGY.

In 1891 the writer described from the Muir glacier basin an argillitic series and a dolomitic limestone, both of great thickness, and both cut by eruptives, in part as great intrusive masses,

*Nat. Geog. Mag., Vol. IV., pp. 56-62.

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in part as dikes.* The eruptives were studied by Dr. Geo. H. Williams,† who determined the main intrusion to be of quartz-diorite, while both acidic and basic dikes occurred, the latter largely predominating, and being in large part diabases. The argillites were the oldest rocks found; the quartz-diorite intrusion was subsequent to the deposition of the limestone, and the dikes cut all the other rocks.

The region is a disturbed one, the time of the disturbance antedating the formation of the dikes, for the most part. The rocks have undergone regional metamorphism, have been tilted, folded, faulted and fractured. The argillites are baked into hard, flinty rocks, which break under the hammer with great difficulty and have totally lost all tendency to split on the old bedding planes, which are only traceable by means of occasional color variations in the different layers. The limestone is also greatly metamorphosed. The whole series is cut up into small blocks by intersecting systems of joints. The tremendous dynamic strains which have acted upon the rocks are made clearly manifest when the quartz-diorite is examined in thin section under the microscope. On the other hand, no such effects are disclosed by the study of the dike rocks. A certain amount of disturbance since the time of dike formation is made apparent by the occasional faulting of a dike, but so far as observed the throw of these later faults is always tolerably insignificant in amount.

The Argillites.—The argillitic rocks have a wide distribution around the eastern side of the Muir glacier basin and also form the mountains adjacent to Muir inlet. They present three main phases:

1. Very hard, fine grained argillo-siliceous bands, gray to brown in color, occasionally approaching quartzite in character.

2. Blue to black, somewhat slaty rocks, nearly as hard as the first and equally fine grained, less siliceous, but containing a slight amount of calcareous matter. These two varieties constitute the main portion of the mass. They separate into small, rectangular blocks along the joint planes, but show no tendency to split along the bedding planes. The blocks are somewhat cemented together by wide-spread secondary calcite in the joints, presumably derived largely from the rocks themselves. Disintegration takes place with amazing rapidity, as shown by the enormous piles of morainic matter furnished to the tributaries of Muir glacier whose valleys are adjoined by mountains of argillite, and by the massive talus heaps that are rapidly

*Nat. Geog. Mag., Vol. IV., pp. 57-62.

†Nat. Geog. Mag., Vol. IV., pp. 65-74.

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accumulating at the bases of other mountains made up of the same material.

3. Thin bands of black, graphitic slates with good slaty cleavage are interstratified with the foregoing varities. There seem to be several such bands, though their apparent number may be increased by faulting.

Careful search for fossils was made in these rocks at several points by the writer, who had his labor for his pains. The series has great thickness, and may comprise rocks of more than one age, but is so homogeneous throughout that its study yields disappointing results. Its base was nowhere seen, but a vertical section of more than 3,000 feet is exposed on Mt. Wright and its outlying ridges which rise from Muir inlet, just below the end of Muir glacier.*

4. *The Glacier Bay Limestone.*—The mountains adjoining the larger part of Glacier Bay consist of dolomitic limestone of a dark color, and for the most part extremely pure, containing only a trace of insoluble matter. Like the argillite, it is metamorphosed and cut up by joints, but the cracks, often widened considerably by solution, are without exception filled by crystalline calcite, binding the whole into a firm mass and much retarding its disintegration. On the peaks east of Muir inlet the limestone may be seen capping the argillites, apparently conformably. Its summit was nowhere seen, but it has an unmistakable thickness of several thousand feet. It may conveniently be designated the Glacier Bay limestone until such time as some other name may prove more appropriate. Fossils in this limestone are rare, and damaged by metamorphism. The writer found them in place on Douglass Island in 1890, and in loose pieces elsewhere, but unfortunanely the recognizable forms gave no precise indication of the age. However, further light has been shed upon this point by the discovery, chronicled by Prof. Stevenson,† of a piece of fossil coral on one of the moraines of the Dirt glacier. A single one of the peaks, amid which the Dirt glacier has its source, is capped by the limestone; otherwise the drainage basin of this glacier lies entirely in argillites or eruptive rocks, so that the locality whence this coral was derived is pointed out beyond question. Prof. H. S. Williams, in a letter to Dr. Reid, pronounces it a species of Lonsdaleia and regards it as demonstrative of the Carboniferous age of the horizon whence it came. As this was apparently the

*The areal geology of the region is delineated so far as may be, on the accompanying map, Plate I., at close. This map was prepared by Dr. Reid for another purpose, is based on his as yet unpublished material, and appears here through the courtesy of the Director of the United States Geological Survey and of Dr. Reid.

†J. J. Stevenson, Scot. Geog. Mag., Feb., 1893, p. 5.

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basal portion of the limestone, the whole will, most probably, prove to be Carboniferous.

Dr. Reid notes the occurrence locally of white, coarsely crystalline marble in considerable force at the upper end of Glacier Bay. Vein fillings of this charater occur at intervals in the argillites and with more frequency in the limestone, but it is possible that these greater masses noted by him may have resulted from contact metamorphism, as they lie in close proximity to the quartz-diorite. The specimens collected show no contact minerals, however.

*The Quartz-diorite.**—As may be seen from the map this rock has a wide distribution in the vicinity. It is quite homogeneous throughout, consisting of white plagioclase, somewhat dull and opaque from decomposition, with frequent thin prisms of hornblende and occasional biotites, and some quartz, the feldspar forming more than one-half the mass and giving it a predominantly white color, by means of which it may be unfailingly recognized at a distance. The only recorded observation on its contact relations is that by the writer made in 1890.† The observed contact was with the argillites, and while the conditions under which it was made were by no means ideal, the contact seemed clearly an irruptive one. Furthermore, the areal distribution of this rock along the upper end of Glacier Bay, as mapped by Dr. Reid, seems to show that there its contact with the limestone is that of an intrusion, and that the white crystalline marble reported there by him may be a phase of the limestone due to contact metamorphism.

One further indication of the order of events in the vicinity is furnished by what seem to be apophysæ from the quartz-diorite, which are found cutting the clastic rocks at some distance from the main intrusion. Three such were noted by the writer in 1890, all of which were several yards in width, no accurate measurements being permissible at the time. They differ slightly from the main mass in appearance, and also carry pyrite in notable quantity, but in thin section are scarcely to be distinguished. They possess the same coarsely hypidiomorphic granular texture, with no variation between the centre and the sides, so far as could be noted, indicating a rate of cooling such as to make it probable that the enclosing rocks themselves had a high temperature at the time of the injection of these relatively small masses, one of which is more than twelve miles distant from the nearest outcrop of the main intrusion.

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*G. H. Williams, Nat. Geog. Mag., Vol. IV., p. 67.

†H. P. Cushing, Nat. Geog. Mag., Vol. IV., p. 61.

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*Diorite.**—The massive moraines on the eastern side of Muir glacier are made up in the main of fragments of a quartz free diorite, which is a more basic rock than the quartz diorite. Numerous blocks of hornblendic gneiss and schist also occur, which may represent foliated phases of this diorite. The large content of such rocks in the moraines leading from the valleys occupied by the McBride, Casement and Girdled glaciers and Berg lake, and from Granite cañon, shows that the enclosing mountains are in great part of diorite, and the color and aspect of these mountains when viewed from a distance give evidence to the same effect. None of these mountains have been reached by parties exploring Muir glacier, so that the nature of the argillite-diorite contact is unknown. But there is a total absence of anything indicating shore conditions as this contact is approached; no pieces of conglomerate have been noted on the moraines, and pieces of fine grained diorite, evidently from dikes, have been found. The diorite is therefore likely to prove of later date than the Carboniferous sediments. So far as known it shows no tendency to grade into the quartz-diorite. They may represent phases of the same intrusion, or different intrusions from the same magma.

Crystalline Schists.—In the collection of rocks made by Dr. Reid in 1892 are specimens of mica schist and actinolite schist, obtained from erratic blocks on the west shore of Glacier Bay, mainly at the northwest corner of Hugh Miller inlet and at the eastern side of the entrance to Geikie inlet. It is of the highest degree of probability that these erratics were brought hither by the glaciers which at present debouch into these inlets, and that therefore outcrops of these schists lie in that direction. Dawson reports frequent areas of schists and gneisses as occurring in the Coast range granite belt, and quite subordinate to the granite in amount, and these may have come from such patches. On the other hand, granites are not represented in Dr. Reid's collection.

Megascopically, the mica schists are finely granular, very schistose rocks with abundant biotite, all of which carry small garnets, and some contain staurolite in addition. Except in the size of the garnets, they precisely resemble the well-known garnetiferous mica schist from the mouth of the Stikine river. The actinolite schists are finely fibrous green schists, mainly composed of actinolite.

Dikes.—All the rocks so far described are cut by numerous dikes, of varying nature but largely of diabase. They are not only younger than the other rocks, but also younger than the

* G. H. Williams, Nat. Geog. Mag., Vol. IV., pp. 65–67.

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time of disturbance and metamorphism of these rocks. In thin section they show no sign of having suffered from the dynamic action which has so profoundly affected the other rocks and whose effect is so beautifully shown in sections of the diorites by the bent and broken crystals, undulatory extinction and production of secondary minerals there exhibited.

While in the main to be classed as diabsses, these dikes shade into andesite-like rocks through loss of the ophitic structure and development of a glassy groundmass. Specimens of more acid rock, rhyolites and micro-pegmatites, are not infrequent on the moraines, but only one such dike has been found in place, and no evidence is at hand as to their relation in time to the basic dikes. These dike rocks much resemble others of known Tertiary age occurring further to the south.*

Comparison With Other Alaskan Sections.

The Coast range belt, of which the region under consideration is structurally a portion, is shut away from the Pacific. north of Cross sound, by the lofty peaks of the Fairweather range. If, as seems probable, this latter belongs structurally with the St. Elias range, it is of a much more recent date.† The Glacier bay section presents many points of similarity with sections described by Dawson and Hayes from British Columbia and southern Alaska, so that a rough correlation may be attempted. A marked feature here is a limestone of great thickness, which, at least in part, is of Carboniferous age. Dawson describes such a limestone from the Dease river holding Fusulina,‡ and another from his section along the Stikine which he believes the same, though finding no fossils.§ Apparently the same limestone is mentioned by Hayes as occurring in the Taku valley.‖ Furthermore Hayes reports black slaty shales apparently underlying the limestone, and Dawson describes from the Stikine a series of " hard argillites and grauwacke-quartzites, interbedded with shaly gray and brownish impure limestones," which were " not observed to hold staurolite, mica, or otherwise crystalline minerals like those of Wrangell, and otherwise differ somewhat in appearance from those."¶ These rocks are below

*For brief petrographic descriptions of specimens from these dikes see G. H. Williams, Nat. Geog. Mag., Vol. IV., pp. 68-74.

†See. H. F. Reid, Nat. Geog. Mag., Vol. IV, p. 24, and G. F. Dawson, Geol. Surv. Can. An. Rep. 1887-8, p. 12 B.

‡G. F. Dawson, Geol. Surv. Can. An. Rep. 1887-8, p. 33 B.

§G. F. Dawson, Geog. Surv. Can. An. Rep. 1887-8, p. 55.

‖C. W. Hayes, Nat. Geog. Mag., Vol. IV., p. 138.

¶Geol. Surv. Can. An. Rep. 1887-8, p. 55 B.

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the limestone which is "of considerable, though undetermined thickness," and rest on the Coast range granites. Precisely the same differences obtain between the Glacier bay argillites and those at Wrangell, Sitka and Junean, and the order of succession is the same in each of the four sections, Stikine, Taku, Dease and Glacier Bay.

The one difficulty encountered in making this correlation is that the strike of the Glacier bay series would bring them over to Lynn canal, and that Dawson reports from the east side of Lynn canal argillites that he likens to those of Wrangell.* In a region so complicated structurally and so little known it is difficult to assign causes for such apparent discrepancies. Beyond this point it is not easy to carry any satisfactory identifications. In the sections of Dawson and Hayes the Coast range granite intervenes between the Palæozoic rocks of the interior and the argillites of the coast, which are perhaps of Mesozoic age. This rock is always reported as a gray granite, and diorite is only reported as occurring in local intrusions in the granite. Quartz-diorite is not reported at all of the four specimens of this granite from the Stikine which were examined microscopically by Dr. Adams,† though one had predominant plagioclase and is stated to appaoach quartz-diorite in character. But the Glacier bay quartz-diorite contains but little orthoclase, and so far as known shows no tendency to grade into granite. Dawson describes the granite as follows: "The Coast ranges, where traversed by the valley of the Stikine and again where crossed still further north by the Chilkoot Pass, are found to consist for the most part of granite and graintoid rocks, almost invariably of gray color, and frequently rich in hornblende. With these are occasionally included stratified or stratiform masses of mica-schists and hornblende-schists, and both these and the granites are frequently traversed by pegmatite veins, diabase dykes and intrusive masses of coarse diorite."‡ Dr. Dawson found here no especial evidence as to the age of this granite, but believes it to be the same as on Vancouver Island, or Middle Mesozoic. On the other hand, Hayes reports basal conglomerates in the Taku valley, resting on what seems to be the same granite, though it may be different, or the conglomerates may not be Palæozoic.

No granite has yet been found in the Glacier Bay section nor on the moraines of the glaciers which come into the bay. Intervening between it and the Fairweather range is a rugged,

* Geol. Surv. Can. An. Rep. 1887-8, p. 32 B.

† F. D. Adams, Geol. Surv. Can. An. Rep. 1887-8, p. 237 B.

‡ Geol. Surv. Can. An. Rep. 1887-8, p. 31 B.

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desolate belt of mountain ranges some thirty to forty miles in width. That this is occupied in large part by the Coast range granite seems quite probable; at least this is likely to be the case if the aparent similarity between the different sections holds good. It is quite likely that the intrusive diorite of Glacier Bay is merely an unusually large sample of the diorite reported by Dawson as intruding into the granite. But nothing like the great quartz-diorite mass of Glacier Bay has been described elsewhere in Alaska. It may represent a phase of the granite, or an intrusion of later date analogous to the diorite. It is more basic than the former, more acidic than than the latter.

Dr. Dawson further reports that the Carboniferous limestone in his Stikine section is followed apparently in ascending order, "by a series of altered volcanic rocks * * * * apparently chiefly diabases, but including also porphyrite like rocks."* These are stated to be bedded, are regarded provisionally as of Carboniferous age, and are likened to rocks forming part of the Câche Creek group, in the southern interior of British Columbia. Rocks of similar character occur on the mountains enclosing the northeast portion of the Muir glacier amphitheatre, which are at least older than the quartz-diorite, being cut by a dike of that rock, one of the apophysæ mentioned on a previous page.

They have not been sufficiently studied to bring out their relations to the Palaeozoic clastics, but as far as observed they are in contact with the argillites instead of lying above the limestone.

The more recent dike rocks, which are of possible Tertiary age, seem widespread throughout the whole extent of the Coast range and are mentioned by every observer.

Petrographical Notes.

The Quartz-diorite.—This rock has been briefly described by Dr. Williams, but in view of its extent and importance in the region a somewhat fuller description seems advisable, though the rock is a quite normal one. Unfortunately the material at hand has not been sufficient to permit of chemical study in conjunction with that under the microscope.

In thin section the quartz-diorite is seen to consist of a coarsely hypidiomorphic granular aggregate of plagioclase, hornblende, quartz and orthoclase (?), with accessory biotite, magnetite, ilmenite, titanite and apatite. The order of crystallization is the usual one, apatite followed by the iron oxides, then titanite, hornblende and biotite, plagioclase, orthoclase (?) and quartz in the order named.

* G. F. Dawson. Geol. Surv. Can, An. Rep., 1887-8, p. 55 B.

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The plagioclase makes up somewhat more than half the rock and is largely idiomorphic, often also with a well-marked zonal structure. The different individuals occur in very varying stages of decomposition in the same slide, and those with the zonal structure have almost invariably the centre more decomposed than the periphery. In the zonal crystals the outer rim never shows a greater extinction angle than 4° in individuals whose twinning lamellæ give nearly symmetrical extinction, while the centre of the same individuals frequently gives an angle of 20° to 22°, indicating a range from oligoclase to a basic andesine or acid labradorite. Inclusions of all the other constituents of the rock except quartz are common.

Along with the undoubted plagioclase in the slides are seen numerous individuals, always so far gone into decomposition that little can be learned from their study concerning their original condition, but which in so far as they retain any indications of twinning whatever, show only that after the Carlsbad law. They are regarded, somewhat doubtfully, as representing an original contest of orthoclase in the rock. The undoubted plagioclase always far exceeds this uncertain feldspar in amount.

Next to the plagioclase hornblende is the most abundant constituent. It is a dark green hornblende with very strong absorption—$\mathfrak{c} < \mathfrak{b} < \mathfrak{a}$—and pleochroism of the usual character in diorite—$\mathfrak{a}$ greenish, $\mathfrak{b}$ dark greenish brown and $\mathfrak{c}$ dark bluish green. The smaller individuals possess sharp crystal boundaries in the prism zone, but the larger individuals are irregularly bounded and everywhere poikilitic, mottled with inclusions of both feldspar and quartz. The maximum extinction angle found is 17°. Inclusions of apatite and the iron oxides are numerous. The ordinary decomposition is to chlorite, but in a few instances epidote also appears. The formation of a light bluish green hornblende with only slight pleochroism, resembling actinolite seems to be an initial stage in the process. Both the feldspar and the hornblende show admirable evidence of the dynamic action to which the rock has been subjected. In addition to widespread undulatory extinction and sliding of portions of crystals along cleavage planes, are many beautiful examples of crystals bent into a curve, extinguishing gradually from one end to the other, the difference amounting to 20° in some cases.

Quartz is present in all the slides and nearly equals the hornblende in quantity. It is totally allotriomorphic and contains frequent inclusions of the other minerals as well as a multitude of minute black inclusions of uncertain nature. A few small patches of granophyric appearance are present.

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The biotite presents no feature of interest except its mode of decomposition. At first its color becomes green with diminished absorption; it then alters to chlorite with the formation of lenses in the cleavage cracks, made up of an aggregate of small particles of a colorless mineral, with high double refraction, which is, in the main, calcite, muscovite being possibly present also. At the same time magnetite (?) forms along the cleavage cracks. Finally the chlorite and magnetite further decompose to a brown earthy mass carrying the calcite lenses.

Titanite appears in all the slides in the customary rhombic cross sections, with an unusually strong pleochroism for that mineral. Apatite abounds in the rock as an inclusion in all the other constituents in the usual minute, clear, sharply defined prisms. Occasional larger irregularly bounded individuals also occur with their customary black dust inclusions.

Pyrite is of frequent occurrence in the quartz-diorite dikes, but does not appear in the main body of the rock.

The microscopic examination suggests that the rock must be a quite acid one lying between normal granite and diorite in that respect.

The Schists.—These present no novel features calling for especial mention. The actinolite schists are finely fibrous aggregations of that mineral, the slender prisms seeming to be arranged in two parallel sets which intersect one another at an angle approximating 20°. The small interspaces are filled with a finely granular mixture of quartz and epidote, and an occasional grain of plagioclase.

The mica schists are fine grained markedly schistose rocks with abundant biotite, which with irregular grains of quartz makes up the main portion of the rock. In two specimens, however, orthoclase occurs instead of quartz, accompanied by a small amount of plagioclase. Small magnetite individuals invariably abound, and all the constituents of the rock are thickly set with black dust-like inclusions, which also seem to be magnetite. Garnets of a light rose color and with numerous inclusions are scattered through the rock. They reach a size of .4 mm. as a maximum. Zircon is also a never-failing constituent.

In two of Dr. Reid's specimens staurolite occurs in numerous short, thick prisms, averaging 6 mm. in length and 3 mm. in breadth, bounded by the faces (110), (001) and (010), and with both twinnings characteristic of the mineral, that parallel to (032) and to (232). It is full of inclusions, notably of quartz and magnetite, and in one case a garnet, .3 mm. in diameter, is completely enclosed in staurolite, indicating the later crystal-

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lization of the latter. Otherwise the garnet is the last formed constituent of the rock.

The Dikes.—The specimens of dike rocks obtained by Dr. Reid, in 1892, are, for the most part, diabases and present no characters additional to those already described from the region by Dr. Williams. There is a specimen of a diorite dike (No. 129), which shows most beautifully the effects of dynamic action, and is evidently far older than the diabase dikes.

WESTERN RESERVE UNIVERSITY, October 24, 1895.

REGULAR BUSINESS MEETING.

November 4th, 1895.

The Academy met with President REES in the Chair; sixteen persons present.

Minutes of the preceding meeting were read and approved.

The nominations for membership of R. E. Dodge and James Marsland Lawton, Jr., were reported approved by the Council, and they were elected by the Academy resident members.

The Section in Astronomy and Physics then organized, and listened to a paper by Prof. R. S. Woodward, upon "Systems of Mechanical Units," Prof. Woodward referred to the importance of the dimensional formulæ in discussing systems of units, and called attention to their introduction in 1821 by Fourier, and their subsequent revival by Maxwell. He pointed out some of the difficulties arising from the adoption of the present fundamental units of length, mass and time, and showed how, by the elimination of either length or time and the substitution of energy, new systems could be obtained. He dwelt upon the desirability of the system in which energy replaces time for those people who may have no conception of time, and pointed out that the conceptions of energy are certainly as distinct as those of mass, and, possibly, even as distinct as those of length and time.

This paper was discussed by Messrs. Pupin, Hallock and Pfister.

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Prof. Harold Jacoby then read a paper received too late for announcement in the Bulletin, on 'Suggestions as to the determination of the relative mass of the two components of the double Star, Eta Cassiopeiæ, from Rutherfurd photographic measures.' Prof. Jacoby outlined the method to be pursued in this investigation, and deduced the formulæ to be used. The calculations will be made by Dr. Davis. The paper was discussed by Prof. Rees.

Prof. Pupin then explained a method of measuring alternating currents with a galvanometer. In consists in placing in the circuit a primary cell and an electrolite cell, whose counter electro-motor force is slightly greater than that of the primary cell. Under this condition only one-half of the alternations passed through the circuit, the other half being stopped by the two cells. Experiments have shown the availability of this method up to 600 alternations per minute.

Prof. A. M. Mayer nominated Prof. E. R. Van Nardroff for resident membership, and the nomination was referred to the Council.

The Academy then adjourned.

J. F. KEMP, *Secretary.*

SUGGESTIONS AS TO THE DETERMINATION OF THE RELATIVE MASSES OF THE TWO COMPONENTS OF THE DOUBLE STAR ETA CASSIOPEIÆ FROM RUTHERFURD PHOTOGRAPHIC MEASURES.

BY HAROLD JACOBY.

The recent publication by the Academy of Rutherfurd's measures of sixty-two stars about Eta Cassiopeiæ, reduced by Dr. Davis, leads me to suggest that these same measures offer the possibility of computing the relative masses of the two components. There is a considerable probability that such a computation will lead to a successful result; and as we have at present only the discussion of this point by Mr. Ludwig Struve, a new investigation will be very interesting and important. It

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is true that the period covered by Rutherfurd's observations is only about three-and-a-half years, or about one fifty-fourth part of the whole period of revolution of the star, and this circumstance is unfavorable to the success of the suggested research. But, on the other hand, the component changed its position during the period of Rutherfurd's observations by about seven-tenths of a second of arc. So that if we adopt Struve's ratio of the masses, which is one to three, the principal star must have changed its position with respect to the centre of gravity of the system by nearly two-tenths of a second. So large a quantity as this could hardly fail to be determined by the Rutherfurd measures, in view of the very large number of comparison stars available. It is, of course, obvious that we should not attempt to determine any of the other elements of the orbit from these measures, but employ in the computations one of the orbits that have been deduced from the measures of the system as a double star. The most recent orbit of this kind is that of Dr. See (Astr. Jour., Vol. XV., p. 54), and this would be the best one to adopt for our present purpose.

The method to be pursued in this investigation appears readily from the following considerations. It is well known that both components of the system revolve about their common centre of gravity, and that this centre of gravity, therefore, is a fixed point in the system. It always lies on the line joining the two components, and divides this line in the inverse ratio of their masses. Consequently, in the apparent orbit, which is the projection of the real orbit, and which is what we actually see on the sky, there is also a fixed point, which is the projection of the centre of gravity. This fixed point always lies on the line joining the apparent positions of the two components on the sky, and it divides that line in the same inverse ratio as before. It is this fixed point, and not the principal star, which should retain a constant distance from all the other surrounding stars on the plate, after the effects of proper motion, parallax, etc., have been removed.

From what has been said, it is clear that if we compute from Dr. See's elements an ephemeris of the minor component referred to the principal star, and if we put:

ρ', θ = the distance and position angle of the minor component, as given by the ephemeris.

M, M' = the masses of the principal star and companion respectively; then if we compute m by the equation:

$$m = -\frac{M'}{M + M'}$$

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we shall have the position of the fixed point in the apparent orbit, referred to the principal star, given by the following coordinates:

$-m\rho'$ for the distance,

θ for the position angle.

It follows that if we let:

$\sigma, p =$ the distance and position angle of any star on the plate from Eta, fully corrected of course for refraction and aberration.

$\sigma' =$ the distance of the fixed point from the same star, we shall have:

$$\sigma - \sigma' = -m\rho' \cos(\theta - p).$$

In establishing equations from whose solution by least squares we are to determine the quantity m, we cannot consider either the parallax or proper motion known. These three quantities are entangled together in such a way that it is impossible to work out either one of them by itself. The first step in the proposed investigation will be to free the measured distances, as given by Dr. Davis, from the effects of variation of scale value. It is almost needless to remark that I propose to use only the distances, and not the position angles measured by Rutherfurd in the present research. To get rid of the variation of scale value, it would seem best to apply such a correction to the scale value of each plate as will make the sum of the distances of the three stars numbered 19, 41 and 62 in Dr. Davis' list, a constant. These stars are on all the plates, and they are favorably situated. The sum of their distances from Eta is 7141″, or 254.9215 divisions of the scale, and their distribution in position angle is such that:

$$\Sigma \sin p = -0.13, \qquad \Sigma \cos p = -0.20.$$

They are therefore admirably adapted for correcting the variation of scale value. To do this, let us put:

$\sigma_{19}, \sigma_{41}, \sigma_{62} =$ the distances of stars 19, 41 and 62 from Eta on any given plate, expressed in divisions of the scale.

Then we must add to every distance on that plate the quantity:

$$\frac{\sigma}{254.92}(254.9215 - \sigma_{19} - \sigma_{41} - \sigma_{62})$$

where σ is the distance of the star from Eta, as given by Dr. Davis, and expressed in divisions of the scale.

The next step is the correction of the distances for proper motion. This is to be done by adding to them the quantity:

$$S_1 P_1 + S_2 P_2$$

where the symbols have the same signification as in Dr. Davis' paper on the Parallax of Eta, p. 301.

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The above steps having been taken, we can proceed to form equations from which to determine by least squares the most probable values of the unknown quantities. These are the two corrections of the assumed proper motion, the parallax, the ratio of the masses, and the true distances of the various stars from the fixed point of the apparent orbit.

Let us introduce the following notation:

ρ, χ = the assumed proper motion on the arc of a great circle, and the position angle of that great circle.

w = the correction required by the assumed $\rho \cos \chi$.

v = the correction required by the assumed $\rho \sin \chi$.

τ = date of the plate *minus* 1872.0.

π = parallax of the system.

S_3, P_3, S_4, P_4 = auxiliary quantities for computing parallax coefficients, and having the same signification as on p. 302 of Dr. Davis' Parallax paper.

σ_0 = the mean of the values of σ on all the plates for any given star.

Then if we put, for convenience:

$$G = S_3 P_3 + S_4 P_4$$
$$x = \sigma_0 - \sigma', \qquad d = \sigma - \sigma_0$$

The following equation will hold true:

$$G\pi + \tau \cos p.\ w + \tau \sin p.\ v + \rho' \cos(\theta - p).\ m + x + d = 0.$$

Such an equation can be formed from each star on each plate, and from their solution the most probable values of the unknowns, π, w, v, m and x, can be determined. From these we pass at once to a knowledge of the ratio of masses by means of the equation:

$$\frac{M}{M'} = -\frac{1+m}{m}$$

and we get the distance from any given star to the fixed point by means of the equation:

$$\sigma' = \sigma_0 - x.$$

The total number of equations will be 702, involving 66 unknowns. But the solution of all these equations by least squares will offer no difficulty, because we can first eliminate the unknown x from all the equations belonging to any given star. The reduced normals from all the stars can then be added together, and the final definitive values of π, w, v, m and x computed. It will probably be possible to tell in advance, from a preliminary consideration of some of the equations, whether the investigation is going to give a satisfactory result. This

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will be the case, if π comes out positive, and m negative, and less than unity. It might even be desirable not to use the method of least squares for the elimination of the x's, but to substitute some other method of elimination, which would take less time, without materially diminishing the precision.

Stated Meeting.

November 11th, 1895.

In the absence of Prof. N. L. Britton, Prof. Henry F. Osborn was elected Temporary Chairman. About forty (40) persons were present.

The minutes of the preceeding meeting of the Section were read and approved.

A report was read by Prof. Osborn regarding the matter of Bibliographical Compilation, which has been brought before the various scientific bodies here and abroad by Dr. Haviland Field, who proposes to establish a regular coöperative bulletin recording the titles of zoölogical and anatomical works. The report recommending the approval by the Academy of the work of Dr. Field was unanimously adopted.

Prof. Rees next brought to the attention of the Section the communication of the Huxley Memorial Committee, it being proposed to erect a statue of the late Professor in the South Kensington Museum, and asking for the coöperation of the New York Academy of Sciences. Upon motion a Committee was appointed by the Chair to take the necessary steps in furtherance of the wishes of the Huxley Committee. This Committee was to consist of Profs. Stratford, Wilson and Huntington and Dr. Wortman.

Owing to the resignation of the Chairman and Secretary of the Section, it was then moved that a nominating committee be appointed by the Chair to consider the question of election of the Sectional officers. To this committee Profs. Lee, Britton and Stratford were appointed.

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The first paper of the evening, that of Prof. Osborn, "A Memorial Tribute to Prof. Thomas H. Huxley," was then presented, and in it were reviewed the main facts of the life of Dr. Huxley, together with many notes of Prof. Osborn, one of his pupils. (See below.)

The second paper was by Dr. Bashford Dean, entitled: "Notes on Ancestral Sharks." The paper dealt with some of the recent discoveries among the fossil sharks of the Lower Carboniferous in Ohio. An examination of this material during the past Summer in the collection of Dr. William Clark, of Berea, Ohio, had enabled the speaker to describe, in addition to the known characters of these primitive forms of Cladoselachids, the vertebral axis, the suspensorium, the matter of claspers and the integumental characters.

The third paper on "Newly Mounted Skeletons of Titanotherium and Metamyodon in the American Museum," with illustrations by Prof. Osborn, was deferred, as were also papers announced by Dr. J. L. Wortman on the "American Museum Expedition of 1895," and by Prof. Britton on "New or Noteworthy North American Phanerogams."

In their place Dr. Arnold Graf spoke of a peculiar growth character in Crepidula, recording the adjustment of its shell to that of a scallop, the margin of the shell of the crepidula conforming exactly to the ridged character of the shell of its host. Discussion by Prof. Martin and Dr. Dean.

The meeting adjourned.

BASHFORD DEAN,
Secretary of Section.

MEMORIAL TRIBUTE TO PROFESSOR THOMAS H. HUXLEY.

BY HENRY F. OSBORN.

Presented before the Section of Biology, November 11th.

All the members of this Academy, all men of science in America, in fact, are in different ways indebted to the late Professor Huxley. We would be ungrateful, indeed, especially in

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this section of the Academy, if we failed to join in the tributes which are being paid to him in different parts of the world.

In his memory I do not offer a formal address this evening, but as one of his students, would present some personal reminiscences of his characteristics as a teacher, and some of the most striking features of his life and work.

Huxley was born in 1825. Like Goethe, he inherited from his mother his brilliantly alert powers of thought, and from his father, his courage and tenacity of purpose, a combination of qualities which especially fitted him for the period in which he was to live. There is nothing striking recorded about his boyhood as a naturalist. He preferred engineering, but was led into medicine.

At the close of his medical course he secured a navy medical post upon the "Rattlesnake." This brought with it, as to Darwin, the training of a four years voyage to the South Seas off eastern Australia and west Guinea—a more liberal education to a naturalist than any university affords, even at the present day. This voyage began at twenty-one, and he says of it: "But, apart from experience of this kind and the opportunity offered for scientific work to me, personally, the cruise was extremely valuable. It was good for me to live under sharp discipline, to be down on the realities of existence by living on bare necessities, to find out how extremely worth living life seemed to be, when one woke from a night's rest on a soft plank, with the sky for a canopy and cocoa and weevily biscuit the sole prospect for breakfast, and more especially to learn to work for what I got for myself out of it. My brother officers were as good as sailors ought to be and generally are, but naturally, they neither knew nor cared anything about my pursuits, nor understood why I should be so zealous in the pursuit of the objects which my friends, the middies, christened 'Buffons,' after the title conspicuous on a volume of the '*Suites a Buffon*,' which stood in a prominent place on my shelf in the chart-room."

As the result of this voyage of four years numerous papers were sent home to the Linnæan Society of London, but few were published; upon his return, his first work, *Upon the Anatomy and Affinities of the Medusæ*, was declined for publication by the Admiralty; a fortunate circumstance, for it led to his quitting the navy for good and trusting to his own resources. Upon publicaton (1849) this memoir at once established his scientific reputation at the early age of twenty-four, just as Richard Owen had won his spurs by his 'Memoir on the Pearly Nautilus.' In 1852 Huxley's preference as a biologist was to turn back to physiology, which had become his favorite

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study in the medical course. But his fate was to enter and become distinguished in a widely different branch which had as little attraction for him as for most students of marine life, namely, palæontology. He says of this sudden change of base:

"At last, in 1854, on the translation of my warm friend, Edward Forbes, to Edinburgh, Sir Henry de la Beche, the Director General of the Geological Survey, offered me the post Forbes had vacated of Palæontologist and Lecturer on Natural History. I refused the former point-blank, and accepted the latter only provisionally, telling Sir Henry that I did not care for fossils and that I should give up natural history as soon as I could get a physiological post. But I held the office for thirty-one years and a large part of my work has been palæontological."

From this time until 1885 his labors extended over the widest field of biology and of philosophy ever covered by any naturalist, with the single exception of Aristotle. In philosophy Huxley showed rare critical and historical power; he made the most exhaustive study of Hume, but his own philosophical spirit and temper was more directly the offspring of Descartes. Some subjects he mastered, others he merely touched, but every subject which he wrote about he illuminated. Huxley did not discover or first define protoplasm, but he made it known to the English-speaking world as the physical basis of life—recognizing the unity of animal and plant protoplasm. He cleared up certain problems among the *Protozoa*. In 1849 appeared his great work upon the oceanic *Hydrozoa*, and familiarity with these forms, doubtless suggested the brilliant comparison of the two-layered gastrula to the adult hydrozoa. He threw light upon the Tunicata, describing the endostyle as a universal feature, but not venturing to raise the Tunicata to a separate order. He set in order the cephalopod mollusca, deriving the spiral from the straight shelled fossil forms. He contributed to the Arthropoda; his last word upon this group being his charming little volume upon the "Crayfish," a model of its kind. But think of the virgin field which opened up before him among the vertebrata, when in 1859 he was the first to perceive the truth of Darwin's theory of descent. Here were Cuvier's and Owen's vast researches upon living and extinct forms, a disorderly chaos of facts waiting for generalization. Huxley was the man for the time. He had already secured a thoroughly philosophical basis for his comparative osteology by studying the new embryology of Von Baer, which Richard Owen had wholly ignored. In 1858 his famous Croonian lecture on the "Theory of the Vertebrate Skull," gave the death blow to Owen's life work upon

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the skull and vertebral archetype, and to the whole system of mystical and transcendental anatomy; and now Huxley set to work vigorously to build out of Owen's scattered tribes the great limbs and branches of the vertebrate tree. He set the fishes and batrachia apart as the *Icthyopsidan* branch, the reptiles and birds as the *Sauropsidan* in contrast with the *Mammalian*, which he derived from a pro-sauropsidan or amphibian stem, a theory which with some modification has received strong recent verification.

Prof. Owen, who had held undisputed sway in England up to 1858, fought nobly for opinions which had been idolized in the first half century, but was routed at every point. Huxley captured his last fortress, when, in his famous essay of 1865, "Man's Place in Nature," he undermined Owen's teaching of the separate and distinct anatomical position of Man. We can only appreciate Huxley's fighting qualities when we see how strongly Owen was intrenched at the beginning of this long battle royal; he was director of the British Museum and occupied other high posts; he had the strong moral support of the government and of the royal family, although these were weak allies in a scientific encounter.

Huxley's powers of rapid generalization of course betrayed him frequently; his *Bathybius* was a groundless and short lived hypothesis; he went far astray upon the phylogeny of the horses. But these and other errors were far less attributable to defects in his reasoning powers than to the extraordinarily high pressure under which he worked for the twenty years between 1860 and 1880, when duties upon the Educational Board, upon the Government Fisheries Commission and upon Parliamentary committees crowded upon him. He had at his command none of the resources of modern technique. He cut his own sections. I remember once seeing some of his microscopic sections. To one of our college junior students working with a Minot microtome Huxley's sections would have appeared like a translucent beefsteak—another illustration that it is not always the section which reveals the natural law, but the man who looks at the section.

Huxley was not only a master in the search for truth, but in the way in which he presented it, both in writing and in speaking. And we are assured, largely as he was gifted by nature, his beautifully lucid and interesting style was partly the result of deliberate hard work. He was not born to it; some of his early essays are very labored; he acquired it. He was familiar with the best Greek literature and restudied the language; he pored over Milton and Carlyle and Mill; he studied the fine old

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English of the Bible; he took as especial models Hume and Hobbes, until finally he wrote his mother tongue as no other Englishman wrote it. Take up any one of his essays, biological, literary, philosophical, you at once see his central idea and his main purpose, although he never uses italics or spaced letters as many of our German masters do to relieve the obscurity of their sentences. We are carried along upon the broad current of his reasoning without being confused by his abundant side illustrations. He gleaned from the literature of all time until his mind was stocked with apt similes. Who but Huxley would have selected the title "Lay Sermons," for his first volume of addresses; or, in 1880, twenty-one years after Darwin's work appeared, would have entitled his essay upon the influence of this work: "The Coming of Age of the Origin of species." Or to whom else would it have occurred to repeat over the grave of Balfour the exquisitely appropriate lines: "We mourn for Lycidas—Dead before his prime." Who else could have inveighed thus against modern specialization: "We are in the case of Tarpeia, who opened the gates of the Roman citadel to the Sabines and was crushed by the weight of the reward bestoyed upon her. It has become impossible for any man to keep pace with the progress of the whole of any important branch of science. It looks as if the scientific, like other revolutions, meant to devour its own children; as if the growth of science tended to overwhelm its votaries; as if the man of science of the future were condemned to diminish into a narrower specialist as time goes on. It appears to me that the only defense against this tendency to the degeneration of scientific workers lies in the organization and extension of scientific education in such a manner as to secure breadth of culture without superficiality; and, on the other hand, depth and precision of knowledge without narrowness."

Huxley's public addresses always gave the impression of being largely impromptu, but he once told me; "I always think out carefully every word I am going to say. There is no greater danger than the so-called *inspiration of the moment*, which leads you to say something which is not exactly true, or which you would regret afterward. I sometimes envy your countrymen their readiness and believe that a native American, if summoned out of bed at midnight, could step to his window and speak well upon any subject." I told him I feared he had been slightly misinformed; I feared that many American impromptu speeches were more distinguished by a flow of language than of ideas. But Huxley was sometimes very impressive when he did not speak. In 1879 he was strongly advocating

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the removal of the Royal School of Mines from crowded Jermyn Street to South Kensington, a matter which is still being agitated. At a public dinner given by the alumni of the School, who were naturally attached to the old buildings, the chairman was indiscreet enough to make an attack upon the policy of removal. He was vigorously applauded, when, to every one's consternation, Huxley, who was sitting at the chairman's right, slowly rose, paused a moment, and then silently skirted the tables and walked out of the hall. A solemn pall fell over the remainder of the dinner and we were all glad to find an excuse to leave early.

In personal conversation Huxley was full of humor and greatly enjoyed stories at his own expense. Such was the following: "In my early period as a lecturer I had very little confidence in my general powers, but one thing I prided myself upon was clearness. I was once talking of the brain before a large, mixed audience and soon began to feel that no one in the room understood me. Finally I saw the thoroughly interested face of a woman auditor and took consolation in delivering the remainder of the lecture directly to her. At the close, my feeling as to her interest was confirmed when she came up and asked if she might put one question upon a single point which she had not quite understood. 'Certainly,' I replied. 'Now Professor,' she said, 'is the cerebellum inside or outside of the skull?'" A story of his about babies is also characteristic: "When a fond mother calls upon me to admire her baby I never fail to respond, and, while cooing appropriately, I take advantage of an opportunity to gently ascertain whether the soles of its feet turn in and tend to support my theory of arboreal descent."

Huxley as a teacher can never be forgotten by any of his students. He entered his lecture room promptly as the clock was striking nine, rather quickly and with his head bent forward "as if oppressive with its mind." He usually glanced attention to his class of about ninety and began speaking before he reached his chair. He spoke between his lips, but with perfectly clear analysis, with thorough interest and with philosophic insight, which was far above the average of his students. He used very few charts, but handled the chalk with great skill, sketching out the anatomy of an animal as if it were a transparent object. As in Darwin's face, and as in Erasmus Darwin's or Buffon's, and many other anatomists with a strong sense of form, his eyes were heavily overhung by a projecting forehead and eyebrows and seemed at times to look inward. His lips were firm and closely set, with the expression of positiveness, and the other fea-

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ture which most marked him was the very heavy mass of hair falling over his forehead, which he would frequently stroke or toss back. Occasionally he would lighten up the monotony of anatomical description by a bit of humor. I remember one instance which was probably reminiscent of his famous tilt with Bishop Wilberforce at the meeting of the British Association in 1860. Huxley was describing the mammalian heart and had just distinguished between the tricuspid valve on the right side of the heart and the bicuspid valve on the left, which you know resembles a bishop's mitre, and hence is known as the mitral valve. He said, "It is not easy to recall on which side these respective valves are found, but I recommend this rule; you can easily remember that the mitral is on the left, because a bishop is never known to be on the right."

Huxley was the father of modern laboratory instruction, but in 1879 he was so intensely engrossed with his own researches that he very seldom came through the laboratory, which was ably directed by T. Jeffrey Parker, assisted by Howes and W. Newton Parker, all of whom are now professors, Howes having succeeded to Huxley's chair. Each visit therefore inspired a certain amount of terror, which was really unwarranted, for Huxley always spoke in the kindest tones to his students, although sometimes he could not resist making fun at their expense. There was an Irish student who sat in front of me, whose anatomical drawings in water color were certainly most remarkable productions. Huxley, in turning over his drawing-book, paused at a large blur under which was carefully inscribed "sheeps' liver" and smilingly said, "I am glad to know that is a liver; it reminds me as much of Cologne cathedral in a fog, as of anything I have ever seen before." Fortunately the nationality of the student enabled him to fully appreciate the humor.

The greatest event in the winter of 1879 was Darwin's first and only visit to the laboratory. They came in together, Huxley leading slowly down the long narrow room, pointing out the especial methods of teaching which he had originated and which are now universally adopted in England and in this country. Darwin was instantly recognized by the class as he entered and sent a thrill of curiosity down the room, for no one present had ever seen him before. There was the widest possible contrast in the two faces. Darwin's grayish-white hair and bushy eyebrows overshadowed the pair of deeply-set blue eyes, which seemed to image his wonderfully calm and deep vision of nature, and at the same time to emit benevolence. Huxley's piercing black eyes and determined and resolute face were full of admiration, and at the same time protection of his older friend. He

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said afterwards, "you know I have to take care of him, in fact I have always been Darwin's bulldog," and this exactly expressed one of the many relations which existed so long between the two men.

Huxley was not always fortunate in the intellectual calibre of the men to whom he lectured in the Royal School of Mines. Many of the younger generation were studying in the universities, under Balfour at Cambridge and under Rolleston at Oxford. However, Saville Kent, C. Lloyd Morgan, George B. Howes, T. Jeffrey Parker and W. Newton Parker are representative biologists who were wholly trained by Huxley. Many others, not his students, have expressed the deepest indebtedness to him. Among these especially are Prof. E. Ray Lankester, of Oxford, and Prof. Michael Foster, of Cambridge. Huxley once said that he had "discovered Foster." He not only singled men out, but knew how to direct and inspire them to investigate the most pressing problems of the day. As it was, his thirty-one years of lectures would have produced a far greater effect if they had been delivered from an Oxford, Cambridge or Edinburgh chair. In fact, Huxley's whole life would have been different, in some ways more effective, in others less so, if the universities had welcomed the young genius who was looking for a post and even cast his eyes toward America in 1850, but in those early days of classical prestige both seats of learning were dead to the science, which it was Huxley's great service in support of Darwin to place beside physics, in the lead of all others in England. Moreover, Oxford, if not Cambridge, could not long have sheltered such a wolf in the fold.

What Haeckel did for evolution in Germany, Huxley did in England. As the earliest and most ardent supporter of Darwin and the theory of descent, it is remarkable that he never gave an unreserved support to the theory of natural selection as all-sufficient. Twenty-five years ago, with his usual penetration and prophetic insight, he showed that the problem of variation might, after all, be the greater problem; and only three years ago, in his "Romanes Lecture," he disappointed many of the disciples of Darwin by declaring that natural selection failed to explain the origin of our moral and ethical nature. Whether he was right or wrong, we will not stop to discuss, but consider the still more remarkable conditions of Huxley's relations to the theory of evolution. As expositor, teacher, defender, he was the high priest of evolution. From the first he saw the strong and weak points of the special Darwinian theory; he wrote upon the subject for thirty years, and yet he never contributed a single original or novel idea to it; in other words,

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Huxley added vastly to the demonstration, but never added to the sum of either theory or working hypothesis, and the contemporary history of the theory proper could be written without mentioning his name. This lack of speculation upon the factors of evolution was true throughout his whole life; in the voyage of the "Rattlesnake" he says he did not even think of the species problem. His last utterance regarding the causes of evolution appeared in one of the Reviews as a passing criticism of Weismann's finished philosophy, in which he implies that his own philosophy of the causes of evolution was as far off as ever; in other words, Huxley never fully made up his mind or committed himself to any causal theory of development.

Taking the nineteenth century at large, outside of our own circles of biology, Huxley's greatest and most permanent achievement was his victory for free thought. Personally we may not be agnostic; we may disagree with much that he has said and written, but we must admire Huxley's valiant services none the less. A reformer must be an extremist, and Huxley was often extreme, but he never said what he did not believe to be true. If it is easy for you and for me to say what we think in print and out of print now, it is because of the battles fought by such men as Huxley and Haeckel. When Huxley began his great crusade the air was full of religious intolerants, and, what is quite as bad, scientific shams. If Huxley had entered the contest carefully and guardedly he would have been lost in the enemies ranks, but he struck right and left with sledge hammer blows, whether it was a high dignity of the Church or of the State. Just before the occasion of one of his greatest contests, that with Gladstone in the pages of the *Contemporary Review*, Huxley was in Switzerland, completely broken down in health and suffering from torpidity of the liver. Gladstone had written one of his characteristically brilliant articles upon the close correspondence between the Order of Creation as revealed in the first chapter of Genesis and the Order of Evolution as shown by modern biology. "When this article reached me," Huxley told me, "I read it through and it made me so angry that I believe it must have acted upon my liver. At all events, when I finished my reply to Gladstone I felt better than I had for months past."

Huxley's last public appearance was at the meeting of the British Association at Oxford. He had been very urgently invited to attend, for, exactly a quarter of a century before, the Association had met at Oxford and Huxley had had his famous encounter with Bishop Wilberforce. It was felt that the anniversary would be an historic one and incomplete without his

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presence, and so it proved to be. Huxley's especial duty was to second the vote of thanks for the Marquis of Salisbury's address—one of the invariable formalities of the opening meeting of the Association. The meeting proved to be the greatest one in the history of the Association. The Sheldonian theatre was packed with one of the most distinguished scientific audiences ever brought together, and the address of the Marquis was worthy of the occasion. The whole tenor of it was the unknown in Science. Passing from the unsolved problems of Astronomy, Chemistry and Physics, he came to Biology. With delicate irony he spoke of the "*comforting word, evolution*," and passing to the Weismannian controversy implied that the diametrically opposed views so frequently expressed nowadays threw the whole process of evolution into doubt. It was only too evident that the Marquis himself found no comfort in Evolution, and even entertained a suspicion as to its probability. It was well worth the whole journey to Oxford to watch Huxley during this portion of the address. In his red doctor-of-laws gown, placed upon his shoulders by the very body of men who had once referred to him as "a Mr. Huxley," he sank deeper into his chair upon the very front of the platform and restlessly tapped his foot. His situation was an unenviable one. He had to thank an ex-Prime Minister of England and present Lord Chancellor of Oxford University for an address the sentiments of which were directly against those he himself had been maintaining for twenty-five years. He said afterwards that when the proofs of the Marquis's address were put in his hands the day before he realized that he had before him a most delicate and difficult task. Lord Kelvin (Sir William Thompson), one of the most distinguished living physicists, first moved the vote of thanks, but his reception was nothing to the tremendous applause which greeted Huxley in the heart of that University whose cardinal principles he had so long been opposing. Considerable anxiety had been felt by his friends lest his voice would fail to fill the theatre, for it had signally failed during his Romanes Lecture delivered in Oxford the year before, but when Huxley arose he reminded you of a venerable gladiator returning to the arena after years of absence. He raised his figure and his voice to its full height, and, with one foot turned over the edge of the step, veiled an unmistakable and vigorous protest in the most gracious and dignified speech of thanks.

Throughout the subsequent special sessons of this meeting Huxley could not appear. He gave the impression of being aged but not infirm, and no one realized that he had spoken his

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last word as champion of the law of Evolution. He soon returned to Eastbourne. Early in the winter he contracted the grippe, which passed into pneumonia. He rallied once or twice and his last effort to complete a reply to Balfour's "Foundations of Belief" hastened his death, which came upon June 29th, at the age of seventy.

I have endeavored to show in how many ways Huxley was a model for us of the younger generation. In the central hall of the British Museum of Natural History sits in marble the life size figure of Charles Darwin; upon his right will soon be placed a beautiful statue of Richard Owen, and I know that there are many who will enjoy taking some share in the movement to complete this group with the noble figure of Thomas Henry Huxley.

STATED MEETING.

November 18th, 1895.

The Academy met with Vice-President STEVENSON in the Chair; about twenty-one persons present.

There being no regular business, the Section in Geology and Mineralogy immediately organized.

The first paper was read by Prof. J. J. Stevenson.

NOTES ON THE GEOLOGY OF INDIAN TERRITORY.

BY JOHN J. STEVENSON.

During a visit to Indian Territory in July of 1895 the writer found opportunity to make some observations tending to unite the work done by Dr. H. M. Chance and Prof. R. T. Hill in that Territory, with that done in Arkansas by Mr. Arthur Winslow, Prof. Hill and Mr. Griswold,* as well as to suggest relationships between the Carboniferous of the Territory and Texas.

* R. T. Hill, Ann. Rep. Geol. Surv. of Arkansas for 1888, Vol. II, pp. 11, et. seq. (1888).
H. M. Chance, Geology of the Choctaw coalfield, Trans. Amer. Inst. M'ng. Eng'rs., Vol. VIII. (1890).
A. Winslow, The geotectonic and physiographic geology of western Arkansas, Bull. Geol Soc. Amer., Vol. II., pp. 225 et. seq. (1891).
R. T. Hill, Notes on a reconnaissance of the Ouachita mountain system in Indian territory, A. J. S., Vol. XLII., pp. 111, et. seq. (1891).
L. S. Griswold, Ann. Rep. Geol. Surv. of Arkansas for 1890, Vol. III., pp. 196 et. seq. (1892).

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Mr. Winslow's final report upon the Coal Measures of Arkansas is still unpublished, but he has given me his table of succession, which is as follows:

I. Poteau Stage, 3300′–3900′, consisting mainly of shale, the Poteau shale. This interval contains several *coal beds*, that mined at Huntingdon and neighboring localities in northwestern Arkansas being the most important and near the base.

II. Sebastian Stage, consisting of

a. Greenwood sandstone, 100′, seen in Indian Territory, just south from Jensen on St. Louis and San Francisco railroad.

b. Tomlinson shale, 500′–600′.

c. Hartwell sandstone, 0′–100′, not present in Indian Territory.

d. Belva shale, 0′–500′, not present in Indian Territory.

e. Ozark sandstone, 0′–500′, not present in Indian Territory.

III. Spadra Stage, 0′–500′, consisting of shales and sandstones with several *coal beds,* the semi-anthracites referred to long ago by D. D. Owen and recently described in Winslow's preliminary report on the Arkansas coals. These beds thin westwardly and are wanting at the Indian Territory line.

IV. Norristown Stage, usually consisting of two sandstones, the upper, from 0′–200′ and the lower, 100′–200′. At the line of Indian Territory, it is represented by one sandstone, 100′ thick.

V. Booneville Stage, consisting of shales and from 400′–2500′. It contains *coal beds*, one below the middle and the other near the base.

VI. Appleton Stage, consisting of

a. Cross Plains sandstone, 50′–150′.

b. Russellville shales, 500′–600′, with thin *coals* near bottom.

c. Washburn sandstones, 500′–600′.

VII. Danville Stage, not differentiated.

The base of the coal measures was not reached in the area studied by M. Winslow, and the beds of the Danville Stage were not measured.

The continuity of the series into Indian Territory is clear even to one traveling on a railroad train, but the erosion is so great that details of succession can be obtained only by patient study supplemented by records of boreholes. The sandstone ridges separated by swales marking areas underlain by shales are easily followed, and their curves exhibit well the structure of the region, while they afford the means of determining the place of the several coal beds. Dr. H. M. Chance spent several months of 1890 in studying the region along the line of the

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Choctaw, Oklahoma and Gulf railway, where he succeeded in working out the succession. His section is as follows:*

Poteau Stage.

1.	Sandstones and shales	1200′
2.	*Kavanaugh coal bed*	4′
3.	Sandstones and shales	4036′
4.	*Secor coal bed*	2′ 6″
5.	Shale	30′

Tomlinson Stage.

6.	Sandstone	50′
7.	Shales	320′
8.	Sandstones	100′
9.	Shales with *coal*, 3′ near bottom	220′

Norristown Stage.

10.	Sandstone	100′

Booneville Stage.

12.	Shales	200′
13.	Sandstone	50′
14.	Shales	130′
15.	*Norman coal bed*	3′
16.	Shales and sandstones, thin coals	600′
17.	*McAlester coal bed*	4′
18.	Shales	500′
19.	Sandstone	100′
20.	Shales with thin coals	700′
21.	*Grady coal bed*	4′

Appleton Stage.

22.	Sandstone, Cross Plains	200′
23.	Shales, not measured.	

Below the shales Dr. Chance found a limestone which he was inclined to regard as possibly Lower Carboniferous.

The highest beds of the column are reached on Kavanaugh and Sugar Loaf mountains, in the Sugar Loaf synclinal of Winslow, which holds the *Huntingdon coal* of Arkansas. Dr. Chance's section evidently reaches higher beds than are found in Arkansas, but it is possible that the thickness may be exaggerated somewhat, as there was no opportunity to check the observations by means of borings. The coal bed, termed by him the *Kavanaugh*, or *Mayberry*, is of indifferent character, and consists of

*The parallelisms with the Arkansas section are by the writer, and Dr. Chance must not be regarded as responsible for them.

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alternations of shale and coal, in all from 3′ 6″ to 5′ 1″ thick. It is evidently one of the higher coal beds found within the Poteau shales in Arkansas. Possibly the bed worked formerly at Poteau station in that synclinal, may be the same with the *Huntingdon coal bed.* But this is only a conjecture, as the beds were not traced.

The Greenwood sandstone of the Sebastian stage could not be recognized on the southerly side of the Sugar Loaf synclinal, there being more than one sandstone which would meet the requirements, and the equivalent of that bed can be determined only by direct tracing from the typical locality in Arkansas, there being no limestones or other definite horizons to save one that labor. The line between the Poteau and Sebastian is drawn arbitrarily.

The Booneville Stage is that of most interest in the Indian Territory and is exposed in a series of narrow, rudely east and west synclines from the Arkansas line and along the Choctaw, Colorado and Gulf railroad to beyond McAlester, on the Missouri, Kansas and Texas railway. Dr. Chance's study of this division was especially detailed and satisfactory. Since his investigations, in 1890, the beds nave been traced eastward from the Choctaw road to the Arkansas line and extensive mining operations have been carried on in the Territory, but all recent investigations tend only to confirm the accuracy of his work.* The Booneville consists of a great mass of shale with beds of sandstone from 50 to 150 feet thick, which form bold ridges, by means of which the coal beds can be traced. Eleven coal beds occur in this series, only two of which have been found economically important. The *Grady coal bed* is at the base of the division, separated by only a few feet, rarely more that forty, from what the writer takes to be the Cross Plains sandstone. It appears to be comparatively unimportant near the Missouri, Kansas and Texas road, but increases in importance eastward and is mined at Hartshorne, in what is known as the Grady basin, and on the St. Louis and San Francisco railroad, at the Bryan mine. It has been traced and proved by prospect holes into Arkansas, where it is shown on the southerly side of Poteau mountain. Its thickness near Hartshorne is from 3′ 6″ to somewhat more than 4′, and the coal is of excellent quality, being clean and bearing handling well. It cokes readily, but no effort has been made to utilize it in that manufacture.

* I am under very decided obligations to Mr. Francis I. Gowen, President of the Choctaw, Oklahoma and Gulf railroad, and to Mr. Edwin Ludlow, General Superintendent of Mines, as well as to Dr. E. N. Wright, of Atoka, for material assistance and for many courtesies while in the Indian Territory. Also to Dr. Chance, who has given me the use of his notes.

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The *McAlester bed*, about midway in this division, attains its chief importance near the Missouri, Kansas and Texas railroad, being mined at McAlester, Krebs and Alderson. It is from 3′ 6″ to 4′ thick at McAlester, but before reaching Arkansas, according to Mr. Mitchell, the Choctaw Coal Company's prospector, it becomes too thin to be of any importance. The coal is good, but is is somewhat tender, and does not bear handling so well as does that from the *Grady bed*; it gives off abundant soot in burning. This bed was worked at one time near Savanna, south from McAlester, but the mine was abandoned owing to increasing steepness of dip. Probably the same bed is mined at Lehigh and Coalgate, about ten miles northwest from Atoka, on a branch of the M. K. and T. railroad, about 35 miles from McAlester; the coal is said to be equally good.

The coals show a notable decrease eastward in the amount of volatile, as one might expect from the Arkansas conditions described by Mr. Winslow. The variations are best shown in the *Grady coal*, as the analyses of that bed have been made from samples collected at mines in several basins between Hartshorne and the Arkansas line. They were made by Mr. A. S. McCreath for Dr. Chance. The fuel ratios are as follows:

1. Average of 8 analyses in Grady basin 1.27
2. Average of 2 analyses in McKinney basin 10 miles east. 1.33
3. Coal from Bryan mine, 20 miles further east 2.10
4. Coal from pit in Mitchell basin near Arkansas line.....3.77

The especial interest lies in the fact that the decrease in volatile bears no relation to the disturbance in the strata, there being no increase of disturbance eastward in Indian Territory or in Arkansas; on the contrary, the disturbance of the rocks shows little change in the Territory, while in Arkansas it practically disappears as one approaches the area of semi-anthracite.

The rocks of the Appleton and Danville stages below the Cross Plains sandstone are not exposed except in a fragmentary way in the shallow ditches through which petty streams flow. That sandstone makes a well defined ridge, which is the southern boundary of the coal region proper. The lower beds are almost wholly shale, only one bed of sandstone, very thin, being rigid enough to form a ridge.

The coal area is cut off abruptly at the south, between the Arkansas line and the Missouri, Arkansas and Texas railroad, by a limestone ridge or rather a succession of ridges, there being at least six of them south from Hartshorne. An exposure of shale at a few rods from the most northerly ridge shows a northward dip, while the limestone in all of the ridges crossed near

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Hartshorne dips southwardly. The first suggestion is that a fault brings up the limestone, but the more probable condition is that of overturned anticlinals, as the anticlinal structure is very distinct in the ridges. One bed was discovered just before our return to Hartshorne, which will yield an abundant harvest to a skillful and patient collector. The specimens obtained at the outcrop are in poor condition and suffice only for determination of the genera. Prof. R. P. Whitfield recognized in them *Zeacrinus*, *Fenestella*, *Eumetria*, *Athyris*, *Nucula*, *Yoldia* and *Cladodus*, with characters referring them to the Upper Carboniferous. This series of ridges is continuous into Arkansas and is the guide to the coal prospector working eastwardly in Indian Territory. The coal measures are reached again south from them, but no mining operations have been undertaken there.

The only limestone seen by the writer above this mass is a thin bed observed along the Missouri, Kansas and Texas railroad south from Savannah, and again on the same road south from the limestone ridge near Atoka. Dr. Chance found a fossiliferous limestone on the Choctaw railroad east from Hartshorne.

From the Arkansas line to McAlester, this coal field has an east and west strike and the structure, as pointed out by Dr. Chance, is Appalachian. One finds here a series of short, overlapping anticlines enclosing typical canoe-shaped synclines, termed by Dr. Chance the Mitchell, McKinney, Grady and McAlester basins. The dips are comparatively gentle, 5 or 6 degrees, where the axes overlap, but become 50 or even 60 degrees along the sides of the basins. And this condition continues for possibly 25 miles westward beyond McAlester. As one approaches McAlester from the east, the overlapping anticlines become stronger and the basins more numerous, so that the outcrop of the coals reaches further south. To what extent the Limestone ridge is affected by these local folds cannot be determined during a hasty ride, for the petty ridges composing it are not persistent, having suffered so much from erosion, so that one might easily be misled as to the direction. It is certain, however, that the ridge, as a whole, is bent southwestwardly from Wilburton on the Choctaw railroad to Limestone Gap, on the Missouri, Kansas and Texas road, in accordance with the widening of the coal area.

At Limestone Gap, 27 miles south from McAlester, the railroad passes through the Limestone ridge and thence runs but little off the strike almost to Atoka, 46 miles south from McAlester. On the southerly side of the ridge the rocks are dipping almost southeastward at not more than 30 degrees. But here

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the trend is changed abruptly and the limestone ridge, which from Wilburton has been holding a widely southwest direction, is bent sharply southward and the dip changes so as to be almost eastward and very steep, 40 to 70 degrees, sometimes little less than vertical. The strike is not true but, as pointed out by Prof. Hill, the limestone appears to be bent westward at several places. This is evidence of overlapping anticlines here as on the Choctaw railroad. The ridge is distinct as far as Stringtown, 38 miles from McAlester, but thence decreasing, it disappears before Atoka has been reached, for it is wanting where its place is crossed by the branch road from Atoka to Lehigh and Coalgate, the only limestone seen along that branch being the thin bed already mentioned as seen just north from Atoka, on the main line. Prof. Hill found it further southward, but the writer failed to discover it at two miles south from the Lehigh branch. The axis must pass very near where the thin limestone was seen, for coal occurs at about two miles west from Atoka, where the rocks are dipping westward. The mines at Lehigh and Coalgate are on the opposite side of the basin.

The abrupt elevation of the Limestone anticline northward affects the distribution of the coal and clearly causes a very rapid narrowing of the basin, for Mr. McConnelly, the Atoka Coal Company's prospector, says that the coal is cut off by the Limestone Hills at several miles north from Coalgate.

It was the writer's intention to go across the country from Lehigh to Dougherty, a station 80 miles away, on the Gulf, Colorado and Santa Fé railroad, but the long-continued heavy rains, unusual in summer, rendered it probable that the rivers could not be forded and the project was abandoned. Limestone in great quantity and with almost vertical dip is reported as occurring at several localities in this interval. Manganese oxide and magnetite have been obtained in limestone, more or less oölitic, at not more than 20 miles from Lehigh, near the line of the proposed Denison and Northern railroad. Limestone is said to occur at Stonewall, also on the Canadian river near the Choctaw railroad crossing, and on the Dougherty road about 25 miles from the latter place. The last may be the work referred to by Prof. Hill as of Silurian age.*

The conditions along the Gulf, Colorado and Santa Fé railroad are wholly unlike those observed in the eastern part of the Territory. At Purcell, on the Canadian river, on the border of Oklahoma, one is in the "Red beds," beds of soft sandstone and

*The region north and south from Lehigh was studied with great care by Prof. Orestes St. John several years ago, but the writer was not aware of this fact until he reached Lehigh, so that he was unable to take advantage of the investigations.

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shale, whose age has not been determined satisfactorily. They bear little resemblance to the Permian beds of Texas, but they are not far from where the Permian beds ought to be. Southward from Purcell to Davis, about 39 miles, the region is broadly rolling prairie without any exposures within a considerable distance from the railroad; but midway between Davis and Dougherty a bold limestone ridge is crossed, whose anticlinal structure is well shown in the deep cuts. This ridge is formed of bare hills passing within a short distance back of Dougherty. As it has a southeasterly trend, it is evidently the anticline passing southeast from that place at the junction of Rock and Buckhorn creeks. It is crossed by the Denison and Northern line at about 6 miles southeast of Dougherty.

On Buckhorn creek, at about 5 miles from Dougherty, a bed of asphaltic limestone was mined as coal some years ago. The fragments seen at the pit were so decomposed that the nature of the rock could hardly be determined. The bed is about 12 feet thick and lies between conglomerates, each about 15 inches. Some bright asphaltum, probably gilsonite, occurs in small quantity. This was used as fuel at Dougherty, but was not satisfactory. It gave off intense heat, but did not break up, and the residuum was removed with difficulty.

The asphalt was seen again near the same stream at about 8 miles from Dougherty, where prospecting was going on for the St. Louis Gilson-Asphaltum Company. The opening is a stripping along the crop, which no longer exhibits the full thickness, which is said to be 14 feet The overlying bed is a conglomerate as at the other exposure, about 18 or 20 inches thick, consisting mostly of calcareous pebbles, but containing some which are silicious and have an onyx-like structure as though they had resulted from replacement. A similar conglomerate is said to underlie the bed, but it is not exposed at the excavation. The asphalt is a tough limestone, very dark brown on the fresh surface, but becoming gray after long exposure. The distribution of the bitumen causes some variation in tint, the lighter color prevailing where the bitumen is concentrated along lines and not evenly distributed. The percentage of bitumen is reported to average not far from 17 and to be as much as 25 in some of the samples. It is said to be rather harder than that in most of the other asphalts brought to the American market. The bitumen fuses when the rock is exposed for several hours to the summer sun of Indian Territory, so that the surface of fragments becomes covered with a brilliant coating. Small bunches of bright asphaltum, said to be gilsonite, are found frequently. The dip at this pit is westward, but the outcrop on the opposite

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side of the trough was pointed out by the foreman of the work.*

A curious and interesting feature is the mode of preservation of the fossils occurring in this rock. They are mostly cephalopods and the shells are as well preserved as are those of mollusks in the Fort Pierre shales. The brilliancy of the nacre is retained, the several laminæ of the larger shells are distinct and in some of the smaller *orthoceratites* the shell is almost translucent. The condition of preservation suggests that the bitumen was introduced at a very early stage of the rock's history. The weathered portions of the rock exhibit broad bands of vegetable origin, the possible source of the bitumen so thoroughly disseminated.†

Prof. Alpheus Hyatt examined the nautiloid forms found here and recognized *Solenocheilus collectus* M. & W., and *Metoceras cavatiformis* Hyatt; the former species being represented by a huge fragment. Other forms occur, but the specimens are too imperfect for identification. *Orthoceras* is abundantly represented, but the forms are not those of the ordinary species and may be new; *Naticopsis altonensis* McCh., *Euomphalus subrugosus*, *Bellerophon* sp. near *B. hiuleus*, *Solenomya* sp. and *Orthis pecosii* were obtained. The rock is abundantly fossiliferous, though the number of forms does not appear to be great.

No fossils were observed in the limestone cut by the railroad north from Dougherty, but the succession is so regular that there seems to be little room for doubt that those beds belong to the Carboniferous, and that they should be put into the Coal Measures. This portion of the section, as is shown by the fossils, is equivalent to the Bend division of the Texas Coal Measures described by Prof. Cummins.‡

Southward from Dougherty, the railroad soon enters the Arbuckle mountains and reaches limestone cliffs within two miles and a half from the station. For somewhat more than two miles further it follows the cañon of Wichita river, whose walls are limestone bluffs in which the beds dip northwest to almost

*Mr. C. O. Baxter, President of the Gilson-Asphaltum Company, informs me that since my visit a new mine has been opened on the opposite side of the trough, about a mile and a half west from this excavation. There the limestone is about 20 feet thick, with barely one-fifth of 1 per cent. of silicious matter. The bitumen is from 8 to 10 per cent. and of what may be termed the normal consistency. The chemical analyses show that this rock is very closely similar to that from Val de Travers and Seyssel. The fossil remains in this pit are reported to be different from those in the other.

†In this connection reference may be made to the fact that petroleum has been obtained in moderate quantity at about 40 miles northeast from Dougherty on a concession belonging to Dr. E. N. Wright. The exploration, however, is not extensive and nothing is known respecting the value of the deposit.

‡Second annual report of the Geological Survey of Texas, 1891, pp. 360-367. Mr. E. T. Dumble, State Geologist of Texas, writes me, that prior to my visit, he had been at Dougherty and had recognized the equivalence of these rocks with the Bend of Texas.

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north, and southeast to almost south, at from 20 to 80 degrees. Prof. R. T. Hill devoted much labor to the investigation of this gorge, but was unable to determine the structure, which is certainly more than ordinarily perplexing. A sharply defined fault is shown in the long side cutting just beyond where the road first reaches the river, and another at the gravel pits, say half a mile further south. The ridge has a southeastward trend and can be traced for a considerable distance even by one riding on a railroad train; but it is cut off abruptly toward the southern border of Indian Territory, where one comes to the lower beds of the Cretaceous.

Prof. Hill's collections in the Wichita gorge proved the occurrence there of palaeozoic rocks from Trenton to Oriskany. Carboniferous beds are found again on the southerly side of the mountains, and near Ardmore is an asphalt deposit, which promises to be of some economic importance.

Direct tracing of the Coal measures from Arkansas into Texas seems hardly possible, for the Cretaceous overlap at the foot of the Ouachita mountains extends for two-thirds of the southern line between Texas and Indian Territory. Prof. Hill's "Red Beds" are shown by him to be continuous from Texas into the Territory around the westerly end of the Arbuckle mountains. But those beds can hardly prove very useful. The writer in company with Prof. Cummins, of the Texas Survey, visited the region whence Permian fossils have been obtained, about 150 miles northwest from Fort Worth. If the beds in that region are the same with the "Red Beds" at Purcell and southward in Indian Territory, one will need fossils to prove the identity, for the lithological characters are wholly dissimilar; still the interval between the localities is considerable and change in characters may be gradual.

The limestones of Indian Territory afford the best means of correlation at present. The Bend stage in Texas, as described by Cummins, is near the base of the Upper Carboniferous; its special fauna is found in the limestones near Dougherty; the limestones of the Choctaw nation occupy a similar place in the section. The writer feels justified in regarding the Choctaw, Dougherty and Bend limestones at practically the same horizon; and in concluding that, during the early portion of the Upper Carboniferous, like conditions prevailed from Arkansas to central Texas. To work out the upper portion of the section in central Indian Territory will prove tedious, as the region has been base-leveled and the rolling prairie shows few exposures.

Messrs. Hill, Winslow, Griswold and Chance have studied the Ouachita mountain system of western Arkansas and the Indian

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Territory, and have recognized the similarity of its structure to that of the Appalachian chain; but while the similarity has been recognized, a notable contrast has been observed, the trend of the Ouachita being approximately east and west, while that of the Appalachian is approximately north and south.

The similarity is indeed very striking, but the contrast is far from being so important as might be imagined at the first glance. The Appalachian type of structure is especially distinct to some distance west from the Missouri, Kansas and Texas railroad. Overlapping anticlines and synclines are numerous, so that the coals in the Choctaw nation are found in basins and the sandstone outcrops follow zigzag lines. The conditions are not so prominently distinct beyond that railroad and southward from the latitude of McAlester, as the region has been base-leveled, and the folds, being less prominent, have less influence on the topography; but the conditions can be traced out without difficulty for many miles southward.

The resemblance to the Appalachian structure, however, is not confined to the overlapping anticlines and synclines; it is equally marked in variation of the trend. At Wilburton, on the Choctaw, Oklahoma and Gulf railroad, about 60 miles west from the Arkansas line, the main trend as shown by the Limestone Hills, is bent south of west, then southwest, and this latter course is held for about 45 miles to Limestone Gap, where it is changed to west of south. This direction continues for 20 miles as followed by the writer, and Prof. Hill appears to have traced it for probably 10 miles more, thus giving about 75 miles for the southerly trend. How much further this course is held cannot be determined, for at a little distance further one comes to the Cretaceous overlap, marked out by Prof. Hill, which conceals the older structure. The Ouachita system, as a topographical feature at least, seems to have its eastern limit not far from Little Rock, Arkansas. The westward trend extends thence to near Wilburton, on the Choctaw railroad in Indian territory, about 140 miles in a direct line; thence the southerly trend continues for not less than 75 miles or somewhat more than one-half of the other.

This is precisely the type of variation shown by the Appalachian trend in Pennsylvania and Virginia. From the Schuylkill river to southern Perry County in the former State, about 90 miles in direct line, the course is south of west; abruptly changing, it becomes west of south and so continues for about 250 miles to near New River, Virginia, where it again becomes south of west, which direction is maintained for about 100 miles, to a short distance beyond the Tennessee line. The sweep of

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trend in each case is quite as sharp as that of the Limestone Hills* in the Choctaw nation. This similarity is so striking that one is tempted to imagine that the Ouachita folds within Arkansas, when followed out in detail, may be found to show a northward bend in their trend and may prove to be connected with some system of folds in Missouri, so that the Ouachita may resemble the Appalachian in a general northeastward and southwestward trend, but with the east and west portions possibly longer than the north and south.

Thus far no reference has been made to the granitic area and the Arbuckle mountains west from the Missouri, Kansas and Texas railroad in the Chickasaw nation. The writer had no opportunity to examine any except the western portion of that region. He is inclined, however, to regard it as belonging to an older system of folds and as wholly independent of the Ouachita, its peculiar structure and singular complexity being in striking contrast to the beautiful simplicity of the Ouachita. Undoubtedly it was affected by the post-Carboniferous elevation of the latter system, to which much of the distortion of dips may be due. To the same cause, indeed, may be attributed the contradictory dips and trends exhibited by the Carboniferous rocks near Dougherty, on the Santa Fé railroad.

The Chickasaw region between the Missouri, Kansas and Texas, and the Gulf, Colorado and Santa Fé railroads deserves careful investigation. The only examination, thus far made, is the reconnaissance by Prof. Hill, which, considering the difficulties under which it was made, was singularly fruitful in results

The second paper of the evening was read by Prof. J. F. Kemp, "Zinc and Lead Mines in Southwestern Virginia."

The paper was based upon a visit of the speaker to the mines the past summer. It showed their geographical distribution and the general geology of the country. By means of lantern views from photographs taken on the spot, the excessive subaerial decay of the blende bearing limestones was made clear, and the occurrence of the zinc in the shape of calamine as crusts upon the decomposed limestone and beneath the overlying mantle of clay. It was stated that the chemical reaction which had lead to the formation of the ore must have taken place at the ordinary temperature, and owing to the influence of the

*These have been selected as they are the special topographic feature of the region The structure is shown equally well by other members of the section, of course.

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common agents, such as carbonated atmospheric waters, sulphuric acid and sulphate of zinc, produced by the decay of the blende and from the action of the silica in the original limestone. The speaker did not attempt to illustrate the matter further, but cited it as an interesting subject for experiment and investigation. The paper was illustrated with numerous specimens and with the lantern. Discussion by the Chairman and others followed.

The Academy then adjourned.

J. F. KEMP, *Secretary.*

PUBLIC LECTURE.

November 25th, 1895.

The first public lecture of the course of 1895–6 was delivered at the Law School of Columbia College by Mr. Cornelius Van Brunt, on "The Natural Flora of Bronx Park."

The lecturer only treated of the flowering plants. His remarks were illustrated by a large series of beautifully colored lantern slides, and was of especial interest on account of the close association of the Academy with the newly organized New York Botanical Garden, which will occupy Bronx Park.

About 150 people were present.

J. F. KEMP, *Secretary.*

STATED MEETING.

December 2d, 1895.

The meeting was called to order, President Rees, in the chair. There were about twenty-five members and guests present.

In the absence of the Secretary, W. Hallock was appointed Secretary *pro tem.* Minutes of preceding meeting were read and approved.

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E. R. Van Nardroff was elected resident member; and H. P. Cushing, of Adelbert College, Cleveland, Ohio, and C. Lloyd Morgan, of University College, Bristol, England, were elected corresponding members.

Prof. N. L. Britton presented the report of the Committee on the Audubon monument, and asked that the Committee be discharged. He reported the satisfactory completion of the monument and the placing of the new die, which was guaranteed for at least two years. He announced that after all the expenses of the monument had been paid a balance of $1,797.25 remained in hand, which the Committee therewith turned over to the Treasurer of the Academy, together with the following resolution:

Resolved, That after all bills incurred by the Committee shall have been paid, the Secretary and Treasurer shall pay over the balance to the Treasurer of the Academy, under the title, "Audubon Publication Fund," the interest of which shall be annually devoted to the publication of a memoir on some zoölogical or botanical topic, if a paper suitable for such memoir shall be presented. If no such paper shall be presented during any one year, the interest shall be allowed to accumulate until one is presented. Memoirs published by this fund shall be so designated.

A committee was appointed to audit the accounts of the report.

There being no further business before the Academy, the Section in Astronomy and Physics then organized, with Prof. Woodward in the chair.

The first paper was by Prof. Harold Jacoby, on "The Determination of Division Errors in Straight Scales." Prof. Jacoby simply read the introduction to the paper and outlined the method. Thereupon, with the permission of the Chairman, he read a historical description of the observatory at the Cape of Good Hope.

The second paper was by C. A. Post, on "Photographs of the Lunar Eclipse of September 2, 1895." The photographs exhibited were very beautiful and brought out some interesting points with reference to the time of exposure.

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The third paper of the evening was by Prof. J. K. Rees, on "Drawings made by Percival Lowell of the Markings on the Planet Mars." These drawings corroborate to a very remarkable degree the observations of Schiaparelli. The drawings provoked an animated discussion in which Profs. Mayer, Rees, Post, Jacoby and Hallock took part. The prevailing opinion seemed to be that, although Mr. Lowell deserved much credit for great application and labor, we must await further corroboration before accepting his rather extreme theories.

The Academy then adjourned.

WM. HALLOCK, *Secretary.*

DECEMBER 2, 1895.

To the New York Academy of Sciences:

Your committee appointed October 3, 1887, with power to solicit funds for the erection of a monument to John James Audubon and to construct the same, would respectfully refer to the reports submitted by them on November 5, 1893, and February 26, 1894, and would further report as follows, and request that they now be discharged.

We have caused the die of the monument, which was found defective after it had been put in place, to be replaced by a new one. This new stone was inserted in May of the present year, and gives every evidence of satisfaction; it is further guaranteed by the following letter from the stonecutters, herewith submitted:

ROBERT C. FISHER & CO., East Houston St.,)
New York, November 13, 1895.)

Dr. Egleston, 35 Washington Square, New York City:

DEAR SIR: We guarantee the Audubon monument from splitting or cracking for a period of two years.

Yours truly, R. C. FISHER & CO.

The committee has paid the balance of the bill due Messrs. Fisher & Co., and would submit the following financial statement:

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STATEMENT.

Total receipts from subscriptions, as reported on Nov. 5, 1893.....	$10,525.21
Interest on sums deposited in the New York Life Insurance and Trust Company, as per vouchers.....	674.91
Total receipts.....	$11,200.12
Disbursements by the committee to Nov. 3, 1893, as reported Nov. 5, 1893.....	$6,645.07
Jan. 25, 1894, Bill of G. R. W. Notman for photographs (voucher 54).....	82.25
Jan. 31, 1894, Wrapping, addressing and postage, reprints, report of committee.....	33.00
Feb. 5, 1894, Bill of the New Era, reprints, report of committee (55).....	22.05
April 5, 1894, Bill of L. S. Foster, extra prints of invitation cards (56).....	10.00
Nov. 16, 1895, Balance due R. C. Fisher & Co., on construction of monument (57).....	2,600.00
Nov. 29, 1895, Postage and clerical assistance to date.....	10.50
Total disbursements.....	$9,402.87
Total	

SUMMARY.

Total receipts of the committee.....	$11,200.12
Total disbursements.....	9,402.87
Balance.....	$1,797.25

Checks for this balance, payable to the order of the Treasurer of the Academy are herewith presented.

In paying over this sum, the following resolution of the committee, adopted May 1, 1893, and accepted by the Academy as a part of the report of the committee on November 5, 1893, is submitted:

Resolved, That after all bills incurred by the committee shall have been paid, the Secretary and Treasurer shall pay over the balance to the Treasurer of the Academy under the title "The Audubon Publication Fund," the interest on which shall be annnally devoted to the publication of a memoir on some zoological or botanical topic, if a paper suitable for such a memoir shall be presented. If no such paper shall be presented during any one year the interest shall be allowed to accumulate until one is presented. Memoirs published by this fund shall be so designated. For the committee,

N. L. BRITTON,
Secretary and Treasurer.

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STATED MEETING.

December 9th, 1895.

The Academy met, with Prof. BRITTON in the chair. There was an attendance of about thirty (30).

In the absence of regular business, the Biological Section at once organized, Prof. William Stratford becoming Temporary Chairman.

On motion of Prof. Stratford, a report of the Huxley Memorial Committee was deferred until the following meeting.

The nominating committee then reported the names of Profs. J. G. Curtis and C. L. Bristol as candidates for the Sectional Chairmanship and Secretaryship, and a motion empowering the Secretary to cast the vote electing them was carried.

Prof. C. L. BRISTOL presented a paper on "The Classification of Nephelis in the United States." He first referred to the various systematic reviews of the genus, and then showed from an examination of a great range of specimens from New England to Dakota that coloration could in no way be depended upon for the determination of species, and that a careful examination of his material, based upon a study of metameral characters, rendered it exceedingly probable that no more than a single species is represented in this country.

Prof. HENRY F. OSBORN, deferring his paper on the "New and Little Known Perissodactyla of the Lower Miocene Lake Basin, South Dakota," referred briefly to the work of the American Museum in preparing for the exhibition of skeletons of the *Titanotheres*, and exhibited a number of drawings and a lantern slide showing the entire skeleton of *Titanotherium robustum*. This is remarkable in possessing but twenty dorso-lumbar vertebræ, a number identical with that typical of the Artiodactyla, but entirely unique among Perissodactyla. It now appears probable that the development of horns in the *Titanotheres* was a purely sexual character, and that the genera *Titanops*, Marsh,

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and *Brontops*, Marsh, are founded respectively upon male and female individuals of the *Titanotherium robustum*.

Dr. J. L. WORTMAN then reported on the "Expedition of 1895 of the American Museum of Natural History," illustrating his paper by many lantern slides. The expedition passed into the Uinta Beds of northeastern Utah, then between the eastern escarpment of the Uinta range and the Green River, into the Washakie Beds of southwest Wyoming. The most important result geologically was the discovery that the Brown's Park deposit is of a much later age than the Uinta.

BASHFORD DEAN,
Secretary of Section.

ADAPTATION OF THE SHELL OF CREPIDULA FORNICATA TO THE SHELL OF PECTEN JACOBÆUS.

BY ARNOLD GRAF, PH. D.

(Read before the Academy of Sciences of New York, Nov. 11, 1895.)

During August, 1895, Mr. Frank Walmsley, preparator, showed me a shell which he had collected, and he was friendly enough to permit me to take a careful sketch of it, in order to write a paper about it. The shell was found at Wood's Holl, Mass., where I happened to be at the time. I express my best thanks to Mr. F. Walmsley, for his kindness in granting me the privilege.

The shell in question is a scallop-shell, on which a specimen of *Crepidula fornicata* is attached. *Crepidula* is often found clinging to *Limulus*, lobsters, scallops and many different shell-fish. As a rule *Crepidula* presents an entirely smooth surface, on which only the concentric growth-lines are conspicuous.

In the present case, however, the *Crepidula* shell shows marked grooves and ridges on its surface, which run in right angles to the growth-lines. This is clearly an adaptation to the well-known ridges in the surface of the scallop.

The case must be a rare one, as in order to get such long ridges we must assume that the animal clung to the scallop when it was quite young, and did not move away during its whole life.

The mechanical cause of the ridges in the shell is very apparent. The edge of the soft "mantel" was pressed unto the surface

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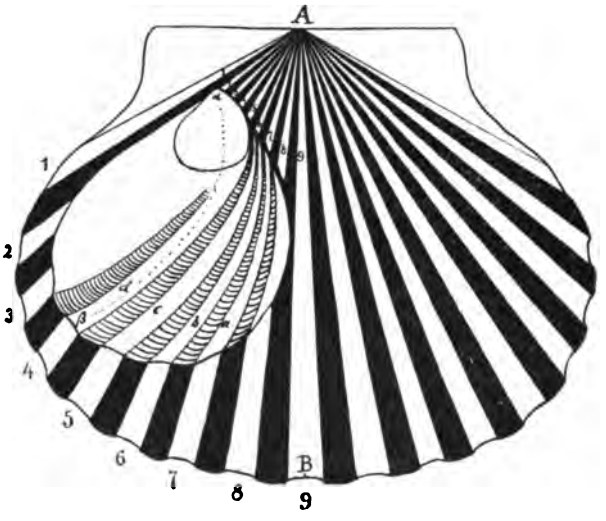
of the pecten-shell and followed closely every groove and ridge of the latter. As the lime-salts, which constitute the shell-substance, were secreted along the edge of the "mantel" they must have been consolidated in the form of the mantel plications.



In the figure I have drawn the pecten-shell with the *Crepidula* in its natural position and in natural size. The ridges of one-half of the scallop-shell are numbered from 1 to 9.

The grooves of the pecten-shell are drawn black, and the grooves of the *Crepidula* are cross-striped.

We see that the four entire grooves, respectively, ridges of *Crepidula* coincide in their proximal and distal points.

The first ridge to the right (a) starts at ridge 7 of the scallop-shell and ends at the same ridge. Ridge b starts at ridge 6 and ends at same, and so forth.

Ridge d is not quite complete, and from this point towards the left side we find no more ridges in the Crepidula-shell. I cannot give any explanation for this fact.

It strikes us that the vertical projection of the ridges in *Crepidula* consists not in straight lines, but in curved ones. It seems as if the furrows of *Crepidula* would cross over the ridges of pecten. Yet this is not the case.

As the first explanatory point I have to mention, that the shell of *Crepidula* is intensely curved, whereas the pecten-shell is nearly flat in comparison.

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This curvature of the shell of *Crepidula* is an unsymmetric one. The radius of the curve is very much shorter on the right side than on the left.

Secondly, the direction of the growth is a different one in the two shells. In *Pecten* the shell grows along a straight line from *A* to *B*, whereas in *Crepidula* the shell grows in a curved line (the beginning of a spiral) from *a* to *b*.

Those two facts (the asymmetry and the spiral growth) explain why the ridges on the surface must be curved very slightly.

I report this case at some length because it seems to me that this may give us some light as to how a new species may be created.

In *Crepidula* we see a form that begins to adapt itself to an ectoparasitic mode of life. It is no parasite yet, but clings to the surface of other animals, and thus profits by the small particles of food that are wasted by the latter.

Crepidula still has a certain power of motion, which it will entirely lose with time.

It is evident that it will be favorable to the species if the individuals cling to those animals that have a rapid motion, as they will in consequence be carried through the water and be in contact with a continually changing medium, fresh oxygen, etc.

We know that *Pecten* is a lamellibranchiate mollusc endowed with a strong power of motion.

Whoever has watched scores of scallops dancing in the water will remember it as an exceedingly pretty sight. The mollusc moves by rapidly opening and closing its valves, pushing out water with great vehemence, and thus progressing in backward jumps. As the water is pushed out with more strength on one side of the animal than on the other, a motion results which is only comparable to a sort of waltz. This motion is very quick and kept on for a very long time.

It is clear that it will be of more use to *Crepidula* to be attached to a quickly moving *Pecten* than to a slowly creeping lobster, or an immobile oyster. Thus we might expect that by natural selection those individuals that are attached to *Pecten* would have more chances to survive. As bye and bye the power of motion will be lost for *Crepidula*, the surface of the animal, which is attached to *Pecten* will present ridges, and thus we may in time obtain a ridged *Crepidula* instead of a smooth one.

Everybody will agree that regular ridges on the surface of a shell constitute an important species character, and out of these facts we may conclude that we shall get a new species in the ridged *Crepidula*.

DEPARTMENT OF BIOLOGY,
COLUMBIA COLLEGE, NEW YORK.

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STATED MEETING.

December 16th, 1895.

The Academy met with Vice-President STEVENSON in the chair; about twenty-five (25) persons present.

The minutes of the last meeting were read and approved.

The Secretary read a petition signed by Nicholas Murray Butler, E. D. Perry, A. V. Williams Jackson, J. R. Wheeler, Thomas R. Price, William H. Carpenter, Henry Alfred Todd and H. T. Peck, expressing their willingness and desire to be elected to membership in the Academy, with a view to forming a Section to deal primarily with scientific investigations in the fields of philosophy and philology. The petition was referred to the Council, with the understanding that it involved the nomination of the signers to resident membership in the Academy, under the conditions stated. The petition was accompanied by a letter from the President of the Academy, endorsing it.

The Section of Geology and Mineralogy then organized.

The first paper was by H. P. Cushing, "Notes on the Areal Geology of Glacier Bay, Alaska." In the absence of the author it was read by the Secretary. The paper is printed on an earlier page of this volume, having been read while in press. It was discussed by J. J. Stevenson, who alluded to his own observations in the same region.

The second paper was by Heinrich Ries, "The Geology of Orange county, New York." Mr. Ries described the results of his field work, performed under the direction of the State Geologist, Prof. James Hall, the preceding summer. His remarks were illustrated by numerous lantern slides. The paper was discussed by the Secretary.

The third paper of the evening was by T. G. White, on "The Faunas of the Upper Ordovician Strata at Trenton Falls, New York." The paper is printed below.

The last paper that had been announced for the evening, by

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J. F. Kemp and T. G. White, entitled "Additional Notes on the Trap Dikes in the Lake Champlain Region," on account of the lateness of the hour was postponed till the next meeting.

The Academy then adjourned.

J. F. KEMP,
Secretary.

THE FAUNAS OF THE UPPER ORDOVICIAN STRATA AT TRENTON FALLS, ONEIDA CO., N. Y.*

BY THEODORE G. WHITE, PH. B., A. M.

Read December 16th, 1895.

PLATES II-V.

CONTENTS.

	PAGE.
History of the term "Trenton Limestone"	71
Original descriptions of the type section	72
Stratigraphy of the Trenton Falls section with faunal lists	74
" " Poland Bridge " " " "	81
" " Poland Limekiln " " " "	82
" " Rathbone Brook " " " "	84
Conclusions	87
Summary	88
Physical features of the Trenton Falls section	89
List of fossils for which Trenton Falls is the type-locality	91
Table of faunas of the various zones	93

Although the original locality from which the Trenton formation derives its name has been so frequently referred to in the literature of that series of strata, the writer was unable to find a detailed tabulation of the stratigraphy or local geological boundaries of the type section, which might be employed as a basis of comparison for similar stratigraphic work, now in progress, upon the Trenton and adjacent terranes in the Lake Champlain valley.

The first mention of the Trenton Falls locality in the reports of the New York State Geological Survey is that by T. A. Conrad in 1837, in his report upon the "Third District," page 163, under the heading "The fœtid limestone and shales of Trenton Falls." These, he informs us, consist of "dark blue limestones and shales, the whole mass probably about four hundred feet in thickness, composing the summits of most of the slopes which descend to the valley of the Mohawk, in Herkimer

* Prepared in connection with a doctorate thesis upon the Trenton Formation in the Lake Champlain valley, soon to be submitted to the faculty of Columbia University.

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and part of Montgomery counties. The rock is here chiefly a fissile slate, but as it passes to the north it assumes, as at Trenton Falls, the character of a dark blue, very hard fœtid limestone, crowded with organic exuviæ, chiefly bivalve shells and fragments of trilobites. The rock has here been cut through by a branch of West Canada Creek, which thus, in a succession of beautiful cascades, leaps through a deep gorge through perpendicular black walls.* * * North of Trenton Falls there is a capping of gray crinoidal limestone, but we are as yet ignorant of its precise character and limits." In the reports of several succeeding years by the various survey geologists the limestone of Trenton Falls is alluded to, and in 1838 Conrad enumerated a few of the fossils from there in his "Sixth group."* Eaton in 1830 applied the name "shelly metalliferous limerock,"† and the formation was "No 2" of the Pennsylvania Survey. The term *Trenton Limestone* was first applied by Vanuxem in 1838,‡ and a few of its characteristic fossils mentioned, but the type section was not defined so as to establish it until his report on the Third District appeared in 1842.§

He says, "At Trenton Falls, there are two distinct varieties: The first is a dark or black colored fine-grained limestone in thin layers, separated by black shale or slate, and which forms the great mass through which the creek has worn its channel and in which are all the falls. The second is a gray coarse-grained limestone in thick layers, which forms the top of the mass. Fossils are extremely numerous in the dark colored part, but are less numerous in the upper or gray part: this latter kind is quite crystalline." Seventeen typical fossils are then described or figured.

The type section of the Trenton, as thus defined, then extends from the bridge just below the milldam at Trenton Falls village to the bridge at Prospect, about two and a quarter miles along the gorge of West Canada creek, more fittingly known by the original Indian name "Kauya Hoora" (Laughing waters). In the course of this two and one quarter miles the river makes a total fall of over three hundred and twelve feet. The dip of the strata is in the direction of the current, and although locally variable, averages less than 10°, so that the path along the canyon ascending with the dip rises at about the same rate as the creek level, except at the falls. Hence the thickness of the beds traversed is greater than it at first seems to be.

* Second Annual Rept. N. Y. State Geol. Survey, p. 115.

† Geological Text-book, p. 38.

‡ Second Annual Rept. on 4th Geol. Dist. of N. Y., pp. 275-276.

§ Geology of New York, Part 3, pp. 45-56.

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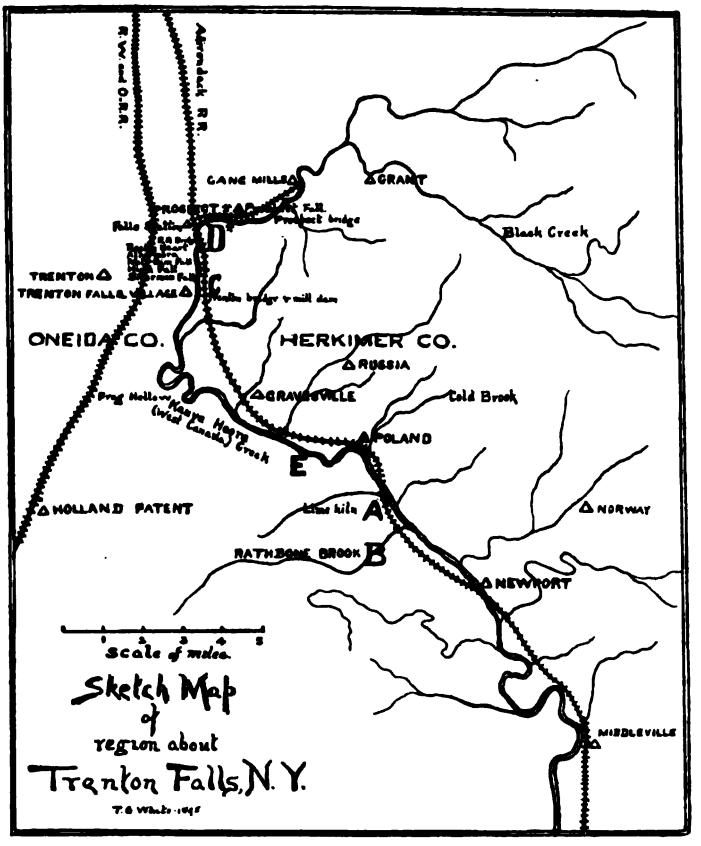

The method of procedure was to start with the geologically lowest layer in each section, measure, and, collecting a quantity of representative material from each successive distinct layer, assign to each a consecutive number, as described in the case of similar work by the writer last summer on Lake Champlain.*

The field numbers have been retained in the left-hand margin of the sections described in the present paper, although in some cases several layers distinguished in the field have been combined, as will be seen, where subsequent laboratory study failed to detect sufficient distinction between them to warrant their separation.

* Trans. N. Y. Acad. Sci. XV., 19 (1895).

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The lowest beds of the type section are seen just below the milldam at Trenton Falls village. In general the lower portion of the formation is most shaly and is inclined to be nodular, but the limestone increases in purity and becomes crystalline in the higher layers. With the exception of the gray crystalline heavy beds in the upper part of the mass, the layers rarely exceed one foot in thickness and are usually two to six inches thick, separated by more shaly layers. As these thin layers vary in hardness they weather at different rates, affording individual prominence. There are, however, several conspicuous seams of hard, dense, blue-black limestone, several feet thick, which continue very constant and therefore form excellent datum levels for measuring up the section.

The walls rise a hundred feet or more high, throughout the length of the gorge; and in spite of local variations of dip, the conspicuous seams may be traced uninterruptedly along the cliffs. One such seam is used for reference in locating the thinner layers until it is cut off by one of the water falls, when we may ascend to a higher level above the fall and there take bearings by an overlying heavy bed. These occasional heavy beds of pure limestone furnish the most perfectly preserved specimens of *Asaphus platycephalus*, for which the Trenton Falls locality is noted. Local collectors inform me that the entire specimens are usually found lying in the rock with ventral surface uppermost.

These conspicuous datum layers are shown in the accompanying photographs: Plate II, showing the heavy bands in Sherman Fall; Plate IV, figure A, a nearer view of one of the blue-black seams (D 11) just above the same fall.

Measured in this way the following results were obtained, here presented in the order in which they were observed, namely, from below upward.*

The specific faunal determinations are based on a rapid study and may need revision with more detailed work. They are, however, sufficiently correct for their intended purpose of establishing the general character of the faunæ of the various zones.

I. Trenton Falls Section—130C+D.

Trenton Falls village bridge to Prospect bridge along Kauya Hoora gorge.

* Note.—The order of names in the faunal lists represents approximately the abundance of the various species, the most abundant being placed first, and if especially numerous designated *a* (abundant), *c* (common), or conversely *r* (rare), etc.

The measurements in the right-hand margin show the height of the top of the layer above the base of the section. The thickness of any layer may then be readily seen by subtraction.

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Section C: Series of broad, nearly horizontal layers, on the east bank of the creek, from beneath Trenton Falls village bridge to the first curve of the creek in the rapids above the milldam.

1 *a* — *g*. Black compact limestone, nodular and especially crinoidal at base, purer at top, with intercalated shaly layers and with a few light-colored lenticles. 10′ 6″

Crinoid fragments a a.
Orthis testudinaria a a.
Orthoceras large* c.
Asaphus platycephalus c.
Calymene senaria c.
Endoceras.
Rafinesquina alternata.
Plectambonites sericea.
Bellerophon bilobatus.
Foraminifera.
Prasopora lycoperdon.

2. Light gray, fine grained sandy layer, composed of comminuted fragments. Breaks readily and in even layers. 10′ 9″

Orthis testudinaria a a.
Rafinesquina alternata a.
Zygospira recurvirostra.
Hyolithes.

3 *a* — *d*. Encrinal shaly layers at the milldam interbedded with more compact fossiliferous layers. About 3 feet are covered by the dam. 17′ 5″

Crinoid stems a a a.
Asaphus platycephalus a.
*Orthoceras** a.
Orthis testudinaria c.

4 *a* — *d*. Hard compact, barren layers, alternating with more impure nodular portions or crystalline lenticles. Fossils in lenticles only. 19′ 10″

Dalmanella testudinaria a a a.
Plectorthis æquivalvis a a.
Asaphus platycephalus c.
Crinoid fragments a a.
Gomphoceras.
Trematis terminalis.
Schizocrania filosa, or a new species.
Calymene senaria r.
Plectambonites sericea r.

5. Shaly at top, impure, nodular, in part compact partly crystalline and partly shaly; lenticular. 21′ 3″

Crinoid fragments a a a.
Prasopora lycoperdon (large celled) a a.
Orthoceras a a.
Zygospira recurvirostra a a.
Asaphus platycephalus c.
Dalmanella testudinaria c.
Stictopora.
Lingula.
Plectambonites sericea.
Ambonychia bellistriata?
Ptilodictya r.
Calymene senaria r.

* This is probably the form mentioned by Vanuxem in his 1842 report (page 47) from these layers, to which he assigns the name of *Orthoceras striatum*. Our specimens are too fragmentary for determination.

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6. Unfossiliferous, rather sandy limestone, weathering yellowish-red, in layers 1 to 5 inches thick; with lighter gray, fossiliferous encrinal, crystalline lenticles, and black compact nodular masses which show especially on the weathered surface. 36′ 3″

Crinoid fragments a a a.
Orthis testudinaria a a.
——— *æquivalvis* a.
——— *biforata* a.
Asaphus platycephalus a.
Rafinesquina deltoidea a.
Calymene senaria c.
Zygospira recurvirostra c.
Trematis terminalis c.
——— n. sp.*
Schizocrania filosa.
Prasopora lycoperdon.
Orthoceras.

It is impossible to follow the eastern shore further in continuation of this section, as the banks become too steep; but crossing to the western bank and descending by the stairs leading down from the hotel the following section is traced.

Section D: 1. At water level below the foot of the hotel stairs, layers, 2 to 8 inches thick. Dip 3° S. Soft, black, shaly; slightly crystalline in portions. Fossils chiefly fragmentary. 9′

Asaphus platycephalus large, a.
Crinoid fragments a.
Calymene senaria.
Rafinesquina alternata c.
Orthoceras.
Orthis testudinaria.
Bellerophon bilobatus.
Trematis terminalis.

2. Compact, nearly barren layers, with only a few specimens of *Orthoceras.* 10′ 8″

3. Fine grained heavy black limestone, with conchoidal fracture, and few more or less perfect fossils. 11′ 6″

Crinoidal columns.
Trinucleus concentricus.
Calymene senaria.
Bellerophon bilobatus.
Rafinesquina alternata.
Orthis testudinaria.
Foraminifera.
Nucula levata r.

4. At landing step of stairs leading down from the hotel. Dip 3°. Heavy bed of very compact nearly black limestone with irregular or conchoidal fracture, in layers 3 to 10 inches thick, irregular and nodular on the surfaces. Frequent well preserved fossils. 18′ 6″

Plectambonites sericea c.
Rafinesquina alternata and some of its peculiar forms with fine striæ.
Asaphus platycephalus large c.
Calymene senaria c.
Orthis testudinaria c.
——— *subæquata.*
——— *æquivalvis.*
Gyroceras.
Murchisonia gracilis.
Tellinomya dubia.
Nucula levata.
Lingula large sp.
Bellerophon bilobatus.
Crinoidal columns.

*Description of this species is deferred until it can be included with other new species in the monograph on the Lake Champlain Trenton referred to at the beginning of this paper. The specific name *T. Trentonensis* will be adopted for it.

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5. Shaly layers, with no distinguishable fossils; not constant. 20′ 6″

6. Dark gray, fine grained limestone in layers 3 to 10 inches thick, with shaly partings, readily cleavable in horizontal layers. The various thin layers weather at different rates. Well preserved fossils. 26′ 6″

Asaphus platycephalus large.
Trinucleus concentricus
Ceraurus pleurexanthemus.
Calymene senaria.
Dalmanella testudinaria.
Lingula—fragments.

7. Heavy, dark colored, nearly barren limestone. The broad seam seen in Sherman Fall. 34′ 6″

8. Finely crystalline, dark gray, very pure limestone splitting readily into regular layers. Contains many comminuted and water worn fragments. 37′

Orthis (*Dalmanella*) *testudinaria.*
Bucania punctifrons.
Rafinesquina alternata.
Lingula riciniformis.
Monticulipora sp. undet.
Hyolithes.
Ptilodictya.
Calymene senaria.
Trinucleus concentricus.

9. Layers forming the top of Sherman Fall. Gray, pure, somewhat crystalline limestone densely packed with *Orthis* (*Dalmanella*) *testudinaria*; the lenticles separated by thin, shaly partings. 41′ 6″

Prasopora lycoperdon large celled c.
————small celled c.
Plectambonites sericea c.
Zygospira recurvirostra.
Nucula levata.
Rafinesquina alternata.
Calymene senaria r.
Asaphus platycephalus r.
Lingula riciniformis.

10. Impure, soft black limestone, with light colored gray crystalline fossiliferous lenticles and thin crinoidal shaly partings. 46′ 6″

Crinoid stems a a.
Zygospira recurvirostra a a.
Plectambonites sericea a.
Orthis (*Dalmanella*) *testudinaria* a.
Rafinesquina deltoidea a.
Asaphus platycephalus c.
Orthoceras large c.
Orthis (*Platystrophia*) *biforata.*
————(*Plectorthis*) *æquivalvis*
Prasopora lycoperdon.
Monticuipora sp. undet.
Rafinesquina alternata.
Calymene senaria.
Trematis terminalis.
Endoceras.
Isachilina small sp.
Bellerophon bilobatus.
Ceraurus pleurexanthemus.

11. First constant heavy "blue black" layer, the bottom following the level of the path above the falls. 49′ 2″

Very pure, hard and barren except for handsome specimens of:—

Calymene senaria.
Asaphus platycephalus.

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12–13. Forming the cliff of High Fall, the bottom being the base of the fall. Shaly at top, impure, and below becoming nodular with dark gray compact, barren concretions and finely crystalline portions, with shaly partings. The barren portions have a conchoidal fracture. The rock weathers into layers two to six inches thick. The fossils are seldom complete, but fragments are abundant. Resembles a cement rock. 139′ 2″

Shaly portion: —

Prasopora lycoperdon.
Zygospira recurvirostra.
Orthis (Dalmanella) testudinaria
Orthoceras.
Rafinesquina nasuta.

Crystalline portion: —

Prasopora lycoperdon, fine celled form, a.
Diplograptus amplexicaule c.
Conularia Trentonensis.
Bryozoan (see also B 14).
Ambonychia bellistriata
Trematis terminalis c.
——— *millepunctata.*
——— small species.
Lingula.
Atrypa deflecta?
Nucula levata.
Bellerophon bilobatus.
Dalmanella testudinaria.
Platystrophia biforata.
Ceraurus pleurexanthemus.
Dalmanites callicephalus.
Calymene senaria.
Orthoceras.
Plectambonites sericea.
Monoprion sp.
Rafinesquina alternata.
Ptilodictya, fine species.
Trilobite, s. nov.
Asaphus platycephalus r.

14. Second "Blue-black" constant layer, rather soft, but compact, with abundant *Calymene senaria*, also *Asaphus platycephalus.* 141′ 5″

15. Alternating shaly with recurrent thinner compact blue-black limestone bands, extending to the top of the chief fall, of High Fall. 201′ 4″

16. Shaly, easily decomposed limestone, showing crushing; first found at top of the third fall; fucoidal markings indicated on the surface, otherwise barren, except for a few *Orthis testudinaria.* 215′ 4″

17. Crinoidal shaly layers, without other fossils. 218′ 4″

18. Layer of light gray, pure, compactly crystalline limestone, weathering yellow, first appearing 40 feet north of the railroad bridge, south of which it pinches out and is not shown at the falls. It contains no fossils except an occasional *Orthis testudinaria.* 224′ 4″

19. Crinoidal shaly limestone, a recurrence of 17, at a point 700 feet north of the railroad bridge, becoming a friable, sandy, crystalline limestone, similar to 18 at top. 227′

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Contains only finely comminuted fragments of:—

Asaphus platycephalus. *Plectorthis æquivalvis.*
Rafinesquina alternata.

20. Gray agglomeration of *Orthis testudinaria*, with black nodules, but no other fossils 229′

21. Zone of *Rafinesquina deltoidea.* Gray finely crystalline limestone with mostly regular cleavage, but impure and slightly nodular in portions, with shaly partings, containing numerous well preserved fossils, notably *R. deltoidea.* Occurs at top of Mill Dam (4th) Fall. 235′

Rafinesquina deltoidea a a a. *Asaphus platyccphalus.*
Orthis (*Platystrophia*) *biforata* c. *Ceraurus pleurexanthemus.*
——— (*Dalmanella*) *testudinaria* c. *Crania Trentonensis.*
Zygospira recurvirostra. *Lingula.*
Crinoid columns.

22. Recurrent shaly layers interbedded with hard, compact to crystalline, blue-black layers, 2 to 10 inches thick, mostly impure and readily weathering. Several conspicuous seams at top. Divided by a seam in the middle into two distinct sets of beds. Forms the whole cliff beneath the gray beds to the top of Mill Dam Fall. Approximately 305′

Rafinesquina deltoidea a a. *Platistrophia biforata.*
——— *alternata* a. *Calymene senaria.*

23. "Trenton Gray Limestone," quarried in the Prospect Quarries on both banks of the creek at the top of the gorge, and shown at the top of the cliff down the gorge to the railroad bridge, as illustrated in Plate V. Heavy bedded, light-gray coarsely crystalline encrinal limestone, very pure and composed of comminuted fragments in which few species can be recognized,† with even shaly partings. 325′

* In the neighboring fields the upper surface of these beds is seen to weather darker, and duller hued and has been dissolved into deep crevasses. The stone from F. T. Thomas' quarry, which is considerably used for building contains $CaCo_3$ 94.82 per cent. and $Mg\ Co_3$ 1.66 per cent. (J. C. Smock, Bull. N. Y. State Museum II., 246, 1890.) Vanuxem says that this "gray limestone commences at Nine Mile Creek, below Stittville, and extends north to near Boonville," and is so fissured at Holland Patent that Cincinnati Creek becomes lost in it. (Second An. Report on Third District, 1838, p. 276.) And again, in his 1842 report already cited, p. 51: "Where the road which leads to Prospect leaves the one from Trenton Village to Boonville, the water of Cincinnati Creek, above the bridge, is seen entering the creek. Higher up, the whole stream is deserted, presenting a rock surface, under which, and by joints of the rock, the water courses by its subterranean route to where it reappears near the bridge." The fossil fragments, especially bryozoa, weather out on the surface in the fields near Prospect. The lower layers are somewhat lighter gray.

† The beds of gray crystalline limestone with their thin shaly partings closely resemble the Trenton as it occurs at the Mile End Quarries, near Montreal, Canada. The latter contains similar fossils, but is slightly bituminous.

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Heavy crystalline beds:—

Orthis (*Platystrophia*) *biforata.*
——— (*Dalmanella*) *testudinaria.*
Monticulipora sp.
Strophomena sp.

Shaly partings:—

Crinoids a a a.
Acidaspis Trentonensis a a.
Orthis (*Platystrophia*) *biforata* a.
Monticulipora sp. a.
Prasopora lycoperdon, large celled c.
——— ———small celled c.
Rafinesquina deltoidea c.
Calymene senaria c.
Bryozoa.
Lingula (*Glossina*) *riciniformis.*
——— larger form, also many fragments.
Ptilodictya sp.
Orthis (*Plectorthis*) *æquivalvis*
——— *subæquata.*
Plectambonites sericea, small form.
——— large ventricose form.
Strophomena planumbona.

This total of 325 feet for the type section compares favorably with Walcott's measurements at Utica,* twenty miles distant, where he obtained a thickness of 350 feet, including the Trenton, Black River and Utica. Vanuxem† estimated the thickness at Trenton Falls at "upwards of 100 feet" only, while Darton‡ states that "there appears to be a thickness of 120 feet." He says, however, that he made no careful measurement and that, "owing to the dip of the beds down stream and the variability of the rate of dip, the total amount of fall is not a measure of the thickness." MacFarland's Geological Railway Guide§ says the formation is 500 feet thick and about seven miles in breadth. Miller's Palæontology of North America‖ says, "the limestone, at the falls is more than 100 feet thick."

The type section of the Trenton is not limited by other formations at either extremity. The creek at Prospect has cut its way deep down into a narrow gorge, so that even the greater altitude of the creek level above Prospect Falls does not bring to light any layers higher than the crystalline beds capping the gorge section. North of here extensive drift deposits cover the country. The nearest occurrence of the Utica is at Nine Mile Creek, East Trenton, where it occurs in the bed of the brook, apparently faulted sharply against the Trenton, but affording no section, and too much covered by water for study at the season at which I visited the district (November).** The Utica here is a fine, rather thick bedded black shale affording Monoprionid graptolites, often at least six inches long, *Triarthrus Becki*, *Lepetopsis*? and *Orthoceras*. There is also said to be a

* Proc. A. A. A. S. XXXVI.: 212.
† Second Annual Rept. of the 3d District (1838), p. 275.
‡ 47th An. Rept. N. Y. State Museum (1895), p. 619.
§ Second Edition (1890), p. 118.
‖ Fourth Edition (1892), p. 40.
** C. D. WALCOTT: Trans. Alb. Inst. X: 18-23 (1883) described ten new species from the "town of Trenton."

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small Utica outcrop in the bed of the creek south of Poland, also presumably a case of faulting, as the formation there is lower Trenton.

At the base of the type section the top of D^6 (page 77) seems to correspond in level nearly with the top of C^4 (page 75), a short distance further down stream, and although the included layers below C^5 only aggregate 19 feet 10 inches against 26 feet 6 inches below D^7 I am nevertheless inclined from their appearance to consider them lower beds, and that some of the beds of D thin out before reaching C, as was the case with layer D 18 in the upper part of the section. Therefore substituting the equivalent layers of C in D we obtain a total thickness of 318 feet 10 inches for the typical Trenton Falls section.

Below the bridge at Trenton Falls village, there are no outcrops along the creek for several miles, the single exception being a small outcrop of nodular impure limestone at the bend of the creek, three-fourths of a mile below the village, near Sawyer Bridge, locally known as "Frog Hollow." The river cuts its way between excellent river terraces of the extensive delta deposits which bury the surrounding country until Poland Bridge is reached. Here, on the west bank of the creek, beneath and just south of the bridge, are seen twenty feet of limestone in layers two to six inches thick, with shaly partings. A small stream cuts the section. The layers are especially prolific, the lower with large specimens of *Prasopora*, and about six feet from the top a particularly rich seam from which the following fossils were chiefly obtained. The fossiliferous portions are notably lenticular and not continuous.

Plectambonites sericea, ventricose var. c.
Orthis (*Dalmanella*) *testudinaria* c.
Rafinesquina deltoidea c.
——— *alternata?*
Strophomena planumbona c.
——— *incurvata.*
Asaphus platycephalus c.
Trinucleus concentricus c.
Calymene c.
Orthis (*Platystrophia*) *biforata* c.
Trematis terminalis c.
Lingula quadrata.
Stenopora fibrosum.
Ceraurus pleurexanthemus.
Orthis subæquata.
Monticulipora.
Orthoceras.
Holopea symmetrica r r.

Near the top of the hill, on the road leading west from the covered bridge just mentioned, another Trenton exposure occurs on the roadside, at an elevation of probably 150 feet above the former. It is a black compact, rather soft limestone and yielded :—

Orthis (*Dalmanella*) *testudinaria* a.
Trinucleus concentricus c.
Modiolopsis faba c.
Rafinesquina alternata c.
Orthoceras.
Ceraurus pleurexanthemus.
Calymene senaria.
Nucula levata.

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Rafinesquina deltoidea.
Strophomena planumbona.
Lingula riciniformis.
Orthis æquivalvis.
*Orthodesma contracta.**
Beyrichia.
Conularia.

For the lowest beds the nearest continuous section was found at

II. POLAND LIMEKILN SECTION—130 A.

On the western bank of West Canada Creek, three miles south of Poland, thence passing upward along the cut of the Adirondack Railroad, which here closely follows the shore, thence across an open meadow, which covers strata estimated at fifteen feet in thickness, to the roadway, and thence through a small abandoned lime quarry and up the hill lying behind it. The latter portion corresponds to the lower portion of the Rathbone Brook Section (**B**), on page 84, which follows the south side of the same hill.

A 1–2. CALCIFEROUS.—light gray, compact, heavy bedded, massive quartzite, weathering yellow; with *Scolithus*-like tubes filled with white quartz. The latter are uniformly vertical in the lower four feet, but above this are not always vertical. In the upper portion the rock is filled with calcite seams and there are shaly portions apparently resulting from crushing. Dip 6° N., but changing further down stream to 6° S. The lowest layers are exposed in the bed of the creek. The total thickness measured above water was.....8 feet.

3–5. BIRDSEYE LIMESTONE.—Ten feet above A^2, on the west side of the railroad cut, the intervening layers being buried beneath debris, is exposed a dove colored limestone with scattered calcite nests, and a flinty conchoidal fracture. Dip 3° S. 40° W. The lower layers have a distinct bite to the touch. The middle layers are the most homogeneous and weather lighter gray, in two to six inch layers. At the top is a bed one foot thick, somewhat crushed on the surface, which weathers yellow.....5½ feet.

6. BLACK RIVER LIMESTONE.—Two heavy barren beds of dark colored compact limestone.....5 feet.

7–8. Capping the foregoing in the railroad cut, and also shown in slightly higher layers in the adjacent field. Nearly black, compact limestone, having conchoidal fracture; weathering gray or yellowish; impure. The rock is barren in some portions, crystalline and highly fossiliferous in others, especially toward the top; the fossils being brought into prominence only by weathering. Chert nodules occur through the rock.

6 feet 9 inches.

* We believe this is the first instance of this Cincinnati species being found in the eastern states.

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This zone is especially characterized by abundant specimens of *Leperditia fabulites* and glabellæ of *Illænus crassicauda.*

Crinoid fragments a.
Avicula Trentonensis c.
Cypricardites obtusus ventricosus c.
Raphistoma Americana c.
Zygospira recurvirostra c.
Rafinesquina alternata.
*Strophomena flitexta** c.
Stictopora c.
Nucula levata.
Tellinomoya nasuta.
Holopea small sp.
Murchisonia.
Orthoceras.
Cyrtoceras tenuistriatus.†
Asaphus platycephalus.‡
Conularia small sp.
Rhynchotrema inæquivalvis.§
Isochilina small sp.
Bathyurus extans.
Orthis cf. *pectinella subæquata.*
Bellerophon sp.
——— small sp.
Protaria vetusta.
Modiolopsis.

Following this about fifteen feet of strata are probably covered, before succeeding beds are reached on the opposite side of the field, in a small lime quarry adjacent to an old kiln on the west side of the roadway, and extending up the side hill behind it.

9. More or less irregular and fractured layers, two inches to one foot thick, partly crystalline and partly shaly, dark gray, breaking in layers, densely packed with *Orthis* (*Dalmanella*) *testudinaria*, with some *Plectambonites sericea* and scattered fragments of *Asaphus platycephalus*, *Bellerophon bilobatus* and *Calymene senaria.*‖ .....32 feet.

10. Very compact, black, thin bedded, shaly limestone, with crystalline bands, shown in the quarry and for 22 feet up the hill, the remainder of the hill being overgrown. It contains few fossils, principally *Rafinesquina alternata*, also *Orthis testudinaria* and *Prasopora lycoperdon.*

Upon the south side of the same hill, however, about one-

* *Strophomena* (*Leptæna*) *flitexta* as figured by Hall, Pal. N. Y., Vol. I., p. 111, Pl. XXXI.B., figs. 3 a-f and as found in the Lake Champlain valley is a broad, very slightly concave species. Winchell and Schuchert, however, in Pal. Minn. III., pt. 1, pp. 385–388, make the Trenton limestone forms of this species synonomous with *Strophomena incurvata* Shepherd (*Producta incurvata* Shep. A. J. S. XXXIV., 144, figs. 1 and 2, 1838) and indicate for it quite as strongly convex a character and outline as in our Black River specimens in this zone. We place it provisionally under this latter name. Except for its strong convexity and almost semi-circular margin, the specimens agree with *S. flitexta* in the character of both external and internal ornamentation.

† *Cyrtoceras corniculum* Hall (Geol. Rep. Wis. 1862, pp. 41 and 441) proved to be a preoccupied name, and Hall therefore proposed to substitute for it the specific name *tenuistriatum.* in S. A. Milller's Am. Pal. Foss. First Ed. p. 243. The species is newly figured under the latter name by Whitfield in Mem. Am. Mus., N. H., I., Pl. IX., 12.

‡ A hypostome found in this material measures 2¼ x 1¾ inches, which, in proportion to one figured in Pal. N. Y., I., Pl. 62, indicates an *Asaphus* having a length of fifteen inches!

§ The specimens from this zone correspond to Hall's figures of *Atrypa increbescens.* Pal. N. Y., I.; Pl. 33, fig. 13 c and fig. 13 k. The former figure according to Winchell and Schuchert, Pal. Minn. III., pt. 1, p. 459, is *R. inæquivalvis* Castelnau, while the latter is *R. capax* Conard. As our specimens most closely resemble figs. 15, 16 and 18 on plate 34 of the Pal. Minn. cited, I place them under Castelnau's specific name.

‖ Rathbone brook is the original locality of this species according to VANUXEM (Geol. 3d district, p. 55) as well as *Trocholites ammonius* Conrad.

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eighth of a mile to the south, the same layers reappear in the much more extensive Rathbone Brook section.

III. Rathbone Brook Section—130 B.

The brook flows into West Canada Creek, near the Black River exposure; and the lowest beds upon it, west of the roadway must occupy a position not far above the Black River. The brook would repay close stratigraphic study, as its meandering course with numerous falls affords a continuous section of conveniently exposed layers for nearly two and one-half miles up the ravine between the hills. The beds dip at about 10° S. 40 W. In order to obtain the relations of the lowest Trenton, collections were limited on this occasion to that portion of the stream between the road running parallel to the creek and the first bridge on the hill road running at right angles to it, a distance of possibly half a mile, up hill. In ascending order these zones are:

B: 1. Thin bedded shaly light gray limestone, lowest beds seen on the south side of the brook, with black partings and fragmental remains in the upper portion, otherwise nearly barren. 12′

Strophomena planumbona.
Orthis testudinaria.
Plectambonites sericea.
Stenopora fibrosum, ventricose variety.
Prasopora lycoperdon of large tubed form.
Calymene senaria.
Asaphus platycephalus.
Trinucleus concentricus.
Ceraurus pleurexanthemus.

2. Lowest layers on north side of brook. Gray, coarsely crystalline with extremely abundant *Prasopora lycoperdon*, growing up in large cylindrical masses. 14′ 6″

Also fragmentary remains of

Orthis (*Platystrophia*, *biforata* a.
Plectambonites sericea c.
Trinuculus concentricus c.
Calymene senaria c.
Ceraurus pleurexanthemus c.
Stenopora fibrosum.
Monticulipora, branching species.
Bellerophon bilobatus.
Murchisonia milleri.
Holopea symmetrica.
Rafinesquina alternata, coarsely ribbed variety.
Crinoid stems, occasional.

3–4. Lower part of first fall. Light gray, pure and very finely crystalline or sandy, with regular cleavage; nearly all the fossils fragmentary. 27′ 2″

Prasopora lycoperdon, large celled form c.
Holopea symmetrica.
Stenopora fibrosum.
Trematis terminalis.
Lingula fragments.
Rafinesquina alternata.

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Trinucleus concentricus.
Asaphus platycephalus.
Ceraurus pleurexanthemus.
Cyrtolites Trentonensis.
Orthis (Platystrophia) biforata.
Orthoceras.
Orthis testudinaria.
Calymene senaria.
Ptilodictya.

5. Heavy barren layer. 31′ 2″

6. Comprising, with 3–5, the first waterfall, and forming with the layers below a zone of *Holopea symmetrica*, not elsewhere located.

Light gray, rather coarsely crystalline with very thin shaly seams and black nodules; rather impure and fracturing irregularly. Recurrent fauna of B^4, but different lithologic characters. 34′ 8″

Holopea symmetrica a.*
Stenopora fibrosum a.
Prasopora lycoperdon.
Trinucleus concentricus.
Asaphus platycephalus.
Ceraurus pleurexanthemus.
Cyrtolites Trentonensis.
Gyroceras.
Orthis (Platystrophia) biforata.
Trematis terminalis.
Lingula riciniformis.
——— *æqualis.*
Plectambonites sericea.
Rafinesquina alternata.
Strophomena planumbona.
Hyolithes.
Murchisonia.
Conularia trentonensis.

7. Alternating barren and shaly layers, the latter containing fragments of *Trinucleus concentricus.* 41′ 8″

8–9. Including the base of the second fall. Light gray, similar to B^6 but not impure; has very regular cleavage; contains some pyrite and many fragmental remains of *Calymene senaria*, *Orthis testudinaria* and *Monticulipora.* 43′ 8″

10–11. Rather impure and finely crystalline, light gray and composed of comminuted fragments with frequent shaly partings. 52′ 2″

Orthis testudinaria.
——— *subæquata.*
Rafinesquina alternata.
Stenopora fibrosum.
Calymene senaria.
Conularia.

12. Shaly layer, containing only *Prasopora lycoperdon*, forming top of the second water fall. 53′ 2″

* Two of the specimens of this species collected in this layer, preserve the original shell material and one the iridescent lustre of the pearl. This is a noteworthy fact considering the age of the fossils—lower Trenton. While several gasteropods and brachiopods with preserved coloration are known from as low as the Subcarboniferous or Devonian [PHILLIPS, J., Geol. Yorkshire II. 226; SARS, M., Annals and Mag. Nat. Hist. 423 (1869); POURTALES, Bull. Mus. Comp. Zool. 126 (1868); DE VERNEUIL, Trans. Geol. Soc. London I. 346 (1842) KEYES, C. R. The Nautilus, IV., 30 (1890.)] the only record I find of shell color preservation from so low a horizon as the Trenton is that of an *Endoceras proteiforme* from New York, described by PROF. O. C. MARSH, Proc. Am. Asso. Adv. Sci. XVI. 326 (1868).

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13. Lenticular, light gray, in portions coarsely crystalline, in other portions highly fossiliferous, although the fossils are chiefly fragmentary, in still other portions with thin, very compact, sandy streaks. 54′

Orthis testudinaria a a a
——— *æquivalvis* a a.
Calymene senaria a a.
Modiolopsis.
Orthoceras.

14. Gray, rather coarsely crystalline, with included compact nodules. 54′ 9″

The latter contain *Calymene senaria* and *Orthroceras*, the former:—

Orthis (*Dalmanella*) *testudinaria* a a a.
Plectambonites sericea a.
Ptilodictya c.
Stictopora.
Prasopora lycoperdon, large celled var.
Orthis (*Platystrophia*) *biforata.*
Calymene senaria.
Nucula levata.
Lingula riciniformis.
——— sp.
Bryozoan, probably new.
Monticulipora.
Rafinesquina alternata.
*Parastrophia hemiplicata.**

15–19. Series of compact barren layers, respectively 2′ 3″; 8″ and 5′ thick alternating with shaly layers containing only *Plectambonites sericea.* 63′ 9″

20–23. A series of gray lenticular beds often composed exclusively of an agglomeration of *Orthis testudinaria*, changing abruptly to very compact, barren, heavily bedded black limestone, with a few very thin shaly partings. 68′ 9″

Orthis testudinaria a a a.
Calymene senaria.
Rafinesquina deltoidea.
——————— *alternata.*
Prasopora lycoperdon.
Monticulipora small.
Crinoid columns.
Plectambonites sericea.

24. A rather impure limestone with scattered fragmentary fossils; black, irregular fracture, compact with scattered calcite crystals and in portions shaly. 72′ 9″

Prasopora lycoperdon small celled. a.
——— large celled form a.
Asaphus platycephalus (large) c.
Clymene senaria c.
Orthis testudinaria c.
———*subæquata.*
Bellerophon bilobatus.
Diplograptus amplexicaule.
Nucula levata.
Tellinomya dubia.
Stenopora fibrosum.
Ptytodictya.
Strophomena incurvata.
Rafinesquina alternata.
———————*nasuta.*
Lingula Curta.
Beyrichia.
Crinoid fragments.
Cyrtoceras.
Orthoceras vertebrata.

*The occurrence of a single specimen of *Parastrophia hemiplicata* in this layer possessed considerable interest. The species is characteristic of the Black River; occurring in that formation at Watertown, N. Y., associated with *Cypricardites latus* Hall. On Lake Champlain we found it to characterize, in great abundance, a well-marked zone, which contained little else. That zone marks the lowest portion of the Trenton for 78 miles along the lake shore. *See Trans. N.Y. Acad. Sci.*, XXV., 20 and 23 (1895).

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25–30. Compact heavy, nearly barren layers, having conchoidal fracture, with intervening shale, the latter containing fragments of:— 102′ 9″

Prasopora. *Lingula curta.*
Crinoid columns. *Orthis testudinaria.*
Asaphus platycephalus. *Orthoceras.*

31. Impure black, breaking irregularly, with calcite seams and a few comminuted fragments of fossils in the purest portion. 114′ 9″

Crinoid fragments a. *Calymene senaria.*
Orthis testudinaria. *Rafinesquina alternata.*

32–33. At the falls near the upper bridge, impure black limestone; the only fossils being scattered *Orthis* and *Asaphus* fragments. 137′ 9″

Conclusions.

Reference to the faunal lists, facilitated by the appended tabulation, suggests several features.

First: The almost universal prevalence of *Orthis testudinaria Rafinesquina alternata*, *Plectambonites sericea*, *Orthoceratites*, *Asaphus platycephalus* and *Calymene senaria* throughout the formation.

Second: The much greater number of forms found in the Black River zones, and in general also in the lower zones than in those above.

Third: The prevalence of *Crinoids*, *Prasopora*, *Rhynchotrema inæquivalvis* and *Trinucleus concentricus*, principally in the lower layers.

Fourth: The appearance of *Parastrophia hemiplicata* so high up in the series in B 14.

Fifth: The first appearance of *Acidaspis Trentonensis*, associated with the most perfect fallen remains of crinoids found, in the uppermost portion, in the shaly partings of the comminuted gray limestone, suggests that the crinoids and the trilobites were killed by the same inflow of muddy water into the purer seas.

Sixth: The absence of various typical Trenton species of frequent occurrence in other localities and not found among the material collected, indicating that they are at least not abundant, if they indeed occur in the region. Some of these species are *Climacograptus*, *Solenopora compacta* Bill, *Orthis occidentalis* Hall, *O. tricenaria* Dalman, *O. subquadrata* Hall, *Leptæna rhomboidalis* Wilck, *Rhynchotrema capax* Con., *Cyclospira bisulcata* Emmons.

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From a lithological standpoint we note:—First, the prevaling shaly, nodular and impure character of the lower portion of the formation.

Second: The tendency of the fossiliferous portions to occur in lenticles, usually of a light gray color, owing to the preponderence of lime, and often composed entirely of an agglomeration of fragments of one or two species. The transition between the light colored fossiliferous and the dark compact limestones often occurs with abrupt contact or line of demarcation; the lenticles evidently being depressions filled up with fragments, in an otherwise even surface of the finest carbonaceous lime sediments.

Third: Judging from the thinness of most of the layers and their frequent shaly partings, oscillations of the sea bottom and successive depositions of fine silts must have followed each other in periods of very brief duration. During a few longer periods quiet seas prevailed which deposited considerable thicknesses of pure limestone of blue-black color, in which the trilobites were entombed entire.

Fourth: Zones, usually of less than one and a-half feet thick of lighter gray color occur chiefly near the central mass, in which the fossils are altogether comminuted. This is also the case with the uppermost gray portion, while many of the fossils of the intervening portion, especially in the *Rafinesquina deltoidea* zone are preserved nearly intact. Finally sedimentation closed with long continued shore deposition, in which the fragments were finely broken or ground to powder, which afterward dissolved and crystallized, and which, possibly owing to the absence of plant life, retained its light color. A few short periods of finer sedimentation intervened between the longer periods of fragmental deposition and preserved the existing fauna.

The subsequent shaly deposits which gradually led to the slate formations of the Utica do not appear at Trenton Falls.

Summary.

The results obtained may be summarized as follows:

Utica shale is not found nearer than Nine Mile Creek, East Trenton, and no upper stratigraphic boundary of the Trenton formation can be found in the type section. The shaly layers following the pure crystalline limestone in other localities and forming the transition to the Utica are not represented.

Trenton Limestone in the Kauya Hoora gorge section consists of:

Upper: Heavy, bedded, gray, coarse crystalline.

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Period of clear seas which furnished quantities of finely comminuted deposits ..... 20 feet.

Middle: Thin bedded, alternating, shaly and purer, dark colored limestone, frequently nodular or lenticular.

Period of oscillating land level and consequent variability of deposition, extending through a long period of time. Lower portion particularly impure and generally encrinal, increasing in purity in the higher layers. Fossils chiefly fragmentary.

316 feet.

Lower: Not seen at Trenton Falls; found at Rathbone Brook, (B) 3¼ miles below Poland. Thin bedded, but more distinctly marked zones than at Trenton Falls. Light colored in general and frequently sandy. Abundant *Prasopora*. Most remains fragmentary. Correspondence with above not yet determined.

BLACK RIVER LIMESTONE.—First seen at the locality (A) three miles south of Poland. Impure, heavy bedded. Fossils numerous and well preserved ..... 11 feet, 9 inches.

BIRDSEYE LIMESTONE. — Heavy bedded, non-fossiliferous, dove colored, dolomitic limestone ..... 9 ft. 6 in.

CHAZY limestone not found, and evidently not deposited.

CALCIFEROUS: Heavy bedded, dolomitic, non-fossiliferous. Underlies the Birdseye at the locality cited ..... 8 feet.

PHYSICAL FEATURES.

These have been noted by Vanuxem, in the report for 1842, on pages 51 to 54, and are worthy of note.

The creek undoubtedly follows a more or less strongly developed series of north and south joint planes, and at Sherman Falls, shown in plate II, has come in contact with a series of joints at right angles to the former, as well shown in the wood cut by R. C. Taylor, on page 52 of the report referred to. The gorge at this point is crossed by a perpendicular wall, extending from the eastern bank (shown on the right-hand side of the illustration in this paper) nearly to the western bank. A portion of the creek at high water still falls over this wall on the right-hand side and centre, as shown; the larger body, however, pours into a second joint lying some twenty or thirty feet behind, and is in process of widening this latter crevice from west to east, so that eventually the original face of the fall will become entirely detached and the fall be obscured behind its rocky screen.

At the top of the lower portion and between it and the upper portion of the High Fall a layer contorted into semi-circular pli-

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cations occurs, interbedded between normally horizontal layers, which constitute a great thickness both above and below. The phenomena is diagrammatically figured by Vanuxem on page 53.

There is a series of these folds, more or less covered by debris at the surface outcrop, three or four of the most striking of which are shown in the photograph (plate III, figure A), especially the one a little to the right of the centre of the view. The trough of the plications bears N. 50° E. The "rim," if we may so term the exterior of the troughs, which most resists weathering on the exposed surface, is of one of the blue-black compact layers, two or three inches thick, so frequent in zone D 15, of which it forms a part. That the distortion has not been accompanied by metamorphism is demonstrated by the fact that the more shaly layers, both within and without this denser "rim," which coincide with its curve, preserve their fossils (*Plectambonites* and *Orthids*) intact. Vanuxem considers that the contortion was due to a crystallization of the "rim" layer, necessitating expansion; while Prof. W. O. Crosby has suggested to the writer that the cause may have been the yielding of this layer under the tremendous weight of strata above. Either theory, however, would imply metamorphism, which does not exist. I am inclined to think that the contortion took place, from some cause, very shortly after the period of deposition.

A photograph of the Great Falls, where the phenomenon occurs, is given by N. H. Darton, Plate X, 47th Annual Report, N. Y. State Museum.

Various peculiar contortions of the strata are to be noted. The first of these is on the eastern face of the narrow passage known as "Rocky Heart," shown in plate III, figure B. The upper layers are nearly horizontal, while those below show overlap structure, due to the subsequent settling and resedimentation upon the original shore. The layers alternately thicken as shown, the stratification following the contact surface with the older sea bottom.

Several other such cases may be noted; and another probably similar instance from the upper end of the gorge, in the layers of section D 22, is shown near the center of plate V, figure A. Near to the latter one of the exits of the underground streams, flowing along the solution crevices of D. 23, pours its rill into the creek from a considerable height.

Near the same locality, also in D 22, there occurs a striking example of what is probably an ancient channel filling, shown in Plate IV, figure B. The edge of the channel forms with the adjacent horizontal layers in which it rests an angle of 8 to 15°. The

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dip of the channel sediments is about 15°. A slight faulting of all the layers occurs at the same locality. This is the same phenomenon illustrated by Vanuxem in the 1842 report on page 54.

LIST OF FOSSILS FOR WHICH TRENTON FALLS IS THE TYPE LOCALITY.

A list of species not contained in the tabulation of those collected by the writer, which will be found on pape 93, but which have been described from Trenton Falls as their type locality. Where no closer designation is appended, the original description only locates them as "Trenton Falls."

Acidaspis parvula Walc. (1879) 31st An. Rep. N. Y. S. Mus. 69.

Bellerophon bilobatus var. *acutus* Hall (1847) Pal. N. Y. I., 185.

——— ——— var. *corrugatus* Hall op. cit. From spec. in Moore collection, Trenton Falls.

Beyrichia bella Walc. (1883). Advance pages of 35th An. Rep. N. Y. S. Mus. 207. From the upper portion of the limestone.

Calceocrinus Barrandii Walc. (1883). Same ref. and location.

Carinaropsis carinata Hall (1847) Pal. N.Y. I. From the black fine-grained layers.

Conchopeltis alternata Walc. (1879) 28th An. Rep. N. Y. S. Mus. 98. From the upper third of the limestone near Prospect Bridge.

Conularia quadrata Walc. (1879) op. cit. Same locality as the last.

Dendrocrinus retractilis Walc. (1883) op. cit.

Endoceras Vanuxemi Con. (1842) Jour. Acad. Nat. Sci. Phila. VIII., 267, Pl. 162.

Glyptocrinus argutus Walc. (1883) op. cit. From upper portion of the limestone.

———————? *subnodosus* Walc. (1883) op. cit. Same locality as the last.

Heterocrinus simplex Walc. (1883) op. cit.

——————— *laxus* Walc. (1883) op. cit.

Iocrinus Trentonensis Walc. (1883) op. cit. From the upper half of the limestone.

Isotelus planus Dekay (1824) An. N. Y. Lyc. N. H. I., 178.

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Lingula rectilateralis Emmons (*Lingula quadrata* Hall (1847) *not* Eichwald). "Usually unassociated with other fossils," in the dark colored central portion.

——— (*Glossina*) *Trentonensis* Conrad (*Lingula attenuata*? Hall, *not* Sowerby). From the dark colored central portion.

Merocrinus typus Walc (1883) op. cit. From the upper portion.

——— *corroboratus* Walc. (1883) op. cit. Same location.

Murchisonia bellicincta Hall (1847) Pal. N. Y. I. From the dark colored upper portion.

Pachydictya acuta Hall (*Stictopora*? *acuta*) (1847) op. cit. Common in the shaly portions.

Palæaster matutinus Hall (1861) (*Asterias matutinus*). Figured Trenton Falls type in Amer. Museum Nat. Hist.

Rafinesquina camerata (Conrad) Hall (1847). Figured specimen (Pal. N. Y. I., Pl. XXXI. A., 2 a–b) from Trenton Falls in Amer. Museum Nat. Hist.

Stictopora elegantula Hall (1847) op. cit. Occurring throughout.

Stomatopora inflata (Hall) Vine (*Alecto inflata* Hall) (1847) op. cit. From the dark, compact central portion.

Streptelasma corniculum Hall (*Streptoplasma corniculum* and *S. multilamellosa* H.) (1847) op. cit. From the lower shaly and gray crystalline portions.

Strophomena Conradi Hall (1892) Pal. N. Y. VIII. 344, is not typically *described* from Trenton Falls, but the original of Pl. XX. 32–32a is from that locality.

Strophomena Trentonensis W. and S. (*Leptæna subtenta* (*Conrad*) Hall, 1847, op. cit.). Occurring throughout.

Making, together with the species noted in the lists on the following pages, a total of forty-one species or varieties for which the types are credited to Trenton Falls.

My thanks are due to Mr. Gilbert van Ingen, of Columbia University and to Prof. R. P. Whitfield, of the American Museum of Natural History, for the determination of specimens, and to the former also for various suggestions; also to Prof. J. F. Kemp for courtesies extended during the progress of the work. No local map of the region being at present obtainable, the one accompanying this paper is based on that in N. S. Benton's History of Herkimer Co., (1856).

GEOLOGICAL DEPARTMENT,
COLUMBIA UNIVERSITY.

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Tabulation of Species Collected from the Various Zones in the Several Sections.

Species to which an asterisk is prefixed were first described from Trenton Falls by their original authorities. The list is by no means an exhaustive one, but represents the general character of the fauna occurring in each zone. The writer will be grateful for information regarding additional species whose stratigraphic position can be similarly located. It seems important to make such a list as complete and minute as possible in the case of the type section of such a prolific formation as the Trenton.

	A			B																		C						D																								E		
	7 8	9	10	1	2	3 4	6	7 9	10 11	12 13	14	15 19	20 23	24	25 30	31	32 33	1	2	3	4	5	6	1	3	4	6	8	9	10	11	12 13	14 18	19	20	21	22	23	1 2	3
Protozoa																																																				
Foraminifera																		×							?																											
Cœlenterata																																																			
* *Diplograptus amplexicaulis* Hall														×																		×																		
Monoprionid																																×																		
Monticulipora, several branching forms				×			×			×		×																×		×								a	×									
Prasopora lycoperdon large celled				×		a	×			×	×			a	×							aa							×	×								×	×									
—— —— small celled			×		×								×	a				×					×						c			a						×										
Protaria vetusta	r																																																	
Stenopora fibrosum Goldfuss				×	×	×	×		×					×																																				
Echinodermata																																																			
Crinoids (fragmentary)	a				×								×	×	×	×		a		aa	aa	aa	aa	a	a	×				aa			×	×		×		aa											
Molluscoidea																																																			
Bryozoa											×																					×						×											
Ptilodictya						×					×			×								r						×			×						×											
Stictopora	c										×											×																												
Brachiopoda																																	?																	
Atrypa deflecta Hall																																					×													
Crania Trentonensis Hall																																																		
Lingula sp.						×					×											×				×	×					×						×	×									
*——— *æqualis* Hall							×																																										
——— *curta* Conrad														×	×																																		

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	A			B																C						D																E	
	7 8	9	10	1	2	3 4	6	7 9	10 11	12 13	14	15 19	20 23	24	25 30	31	32 33	1	2	3	4	5	6	1	3	4	6	8	9	10	11	12 13	14 18	19	20	21	22	23	1 2	3
BRACHIOPODA (continued).																																									
Lingula (*Glossina*) *riciniformis* Hall							×				×																×	r												×	
Orthis (*Plectorthis*) *æquivalvis* Hall										×											aa		a			×				×					×				×	
——— (*Platystrophia*) *biforata* (Schl.) Bill.					×	×	×				×												a							×		×			×	×	×	×	
——— (*Dinorthis*) *pectinella* (Emmons) Hall	×																																							
——— *subæquata* Conrad	?								×					×												×											×	×		
——— (*Dalmanella*) *testudinaria* Dalman		×	×	×		×		×	×	×			aa	c	×	×	×	aa	aa	a	aa	c	aa	×	×	×	×	×	aa	a		×	×		×	a		×	c	a
Parastrophia hemiplicata Hall											×																														
Plectambonites sericea (Sowerby) Hall	×	×		×	×		×				×	×	×					×			r	×				×			c	a		×					×	×	
* *Rafinesquina alternata* (Conrad)	a		×		×	×	×		×		×		×	×		×		×	a					c	×	a		×	×	×		×		×			×	×	c
*——— *deltoidea* (Conrad). Note *a*.													×										c							a					aa	aa	c	×	×
——— *nasuta* Conrad														×																	×									
* *Rhynchotrema inæquivalvis* Castelnau	×																																							
Schizocrania filosa Hall																																								
Strophomena incurvata (Shepherd) W. & S.	×													×								×																	×	
——— *planumbona* Hall				×			×																																c	×
Trematis millepunctata Hall.																																								
——— *terminalis* (Emmons) Hall						×	×														c		c	×					c		c							c	
——— n. sp.																							X																	
Zygospira recurvirostra Hall	c																		×			aa	c					×	aa		×				×				
PTEROPODA.																																								
Conularia sp?									×																															?
——— small sp.	×																																							
*——— *Trentonensis* Hall							×																								×								
Hyolithes							×												×								×												

NOTE *a*. Possible types of Conrad's species have been found by the writer in Col. Phila. Acad. Nat. Sci. labeled "Trenton Limestone N. Y."

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	A			B																												C						D																		E	
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GASTEROPODA.																																																											
Bellerophon bilobatus Sowerby		×			×									×				×						×	×	×				×		×																							
——— sp.	×																																×																						
Bucania punctifrons Emmons																												×																												
Cyrtolites Trentonensis						×	×																							e																								
Holopea symmetrica Hall				×	×	c																																																	r	
——— small species	×																																																						
Murchisonia gracilis Hall																					×																																		
——— *Milleri* Hall					×																																																		
——— sp	×			×		×																																																
Raphistoma Americana Bill	c																																																						
CEPHALOPODA.																																																							
Cyrtoceras														×																																									
——— *tenuistriatum* Hall	×																																																					
**Endoceras proteiforme* Hall, Note *b*																		×												×																							
Gomphoceras																						×																															
Gyroceras							×														×																															
Orthoceras sp.	×				×					×	×				×			c		a		aa	×	×					×		×																				×	✓
——— *vertebrata* Hall, 1847														×																																						
LAMELLIBRANCHIATA.																																																					
**Ambonychia bellistriata* Hall, Note *c*																						?										×																					
Cypricardites obtusus Hall	c																																																			
*——— *ventricosus* Hall	×																																																			
Modiolopsis sp.	×									×																																										
——— *faba* Emmons																																																				
* *Nucula levata* Hall	×										×			×											×	×			×		×																					×

NOTE *b*. Original specimens illustrated in Pal. N. Y., I. Pl., LVII.: 1 *a-b* from Trenton Falls, are now in Amer. Mus. Nat. Hist.
NOTE *c*. Pl. N. Y. I: Pl. XXVI.: figs. 4*a-c*, originally figured from types in Moore collection at Trenton Falls. Type of 4*a* now in Amer. Mus. Nat. Hist.

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	A			B																C						D																								E	
	7 8	9	10	1	2	3 4	6	7 9	10 11	12 13	14	15 19	20 23	24	25 30	31	32 33	1	2	3	4	5	6	1	3	4	6	8	9	10	11	12 13	14 18	19	20	21	22	23	1 2	3
LAMELLIBRANCHIATA (Continued).																																																	
Orthodesma contracta Hall & Whitf.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pterinea Trentonensis Conrad.	c	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
* *Tellinomya dubia* Hall	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...
* ——— *nasuta* Hall.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
CRUSTACEA																																									
Acidaspis Trentonensis Hall	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...
Asaphus platycephalus Stokes, Note *d*	×	×	...	×	...	×	×	...	...	...	...	...	...	c	×	...	×	c	...	a	c	c	a	a	...	×	×	...	r	c	×	×	×	×	...	×	...	...	c	...
Bathyurus extans Hall.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Beyrichia	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×
Calymene senaria Conrad	...	×	...	×	c	×	...	×	×	aa	×	...	×	c	...	×	...	c	...	...	r	r	c	c	c	×	×	×	r	×	×	×	×	...	...	...	×	c	×	×
Ceraurus pleurexanthemus Green.	...	...	...	×	c	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	×	...	×	...	...	×	...	...	...	×	×
Dalmanites callicephalus Hall	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
Illænus crassicauda Wahl	a	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Isochilina small sp.	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...	...
Leperditia fabulites Con.	a	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Trinucleus concentricus (Eaton) Hall	...	...	...	×	aa	×	×	×	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	×	×	...	...	...	...	...	...	...	...	...	×	c
Trilobite n. sp.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	×	...	...	...	...	...	...	...	...
Total species recorded	79	28	5	3	9	14	15	18	4	6	6	15	1	8	20	6	4	2	11	4	4	9	12	13	8	8	14	6	9	10	18	2	26	4	4	1	9	4	17	19	15

NOTE *d*. Syn. *Isotelus gigas* Dekay. Ann. N. Y Lyc. N. H. I: 176, Pl. XII, I. Pl. XIII, 1. (1824) which was originally described from Trenton Falls specimens. Type of the large specimen, figured in Pal. N. Y. I; Pl. LXIII, was from Moore collection, Trenton Falls.

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Regular Business Meeting.

January 1, 1896.

In the absence of the President, the meeting was called to order by Prof. Woodward. There were twenty-six members and guests present.

The minutes were read and approved.

Dr. Franz Boas, of the American Museum of Natural History, was nominated as resident member.

Prof. M. I. Pupin then read before the Section of Astronomy and Physics a paper on the "Magnetic Circuit." In transformers, especially of closed iron core, it has long been known that the upper "harmonics" of the fundamental rate of alternators, present in the primary are choked out by the transformer leaving the potential difference of the secondary coil represented by a simple sine curve. The choking out is less if the magnetic circuit is incomplete and least where the coils have no magnetic core. Various explanations have been offered to account for this phenomenon; and it is doubtless true that it is due to Foucault currents and to hysteresis. Dr. Pupin pointed out from certain mathematical considerations that by appropriate measurements, especially of the angle of *lag*, it would be possible to separate the energy consumed in Foucault currents from that consumed by hysteresis, and thus be able to study this latter puzzling phenomenon. Investigations are in progress to test the method experimentally. Prof. Crocker remarked upon the interest and importance of the questions involved.

The second paper was by Dr. A. A. Julien upon "The Condensed Gas Film on the surface of Solid Bodies with relation to (1) Newton's rings of the first order; (2) Sand flotation; (3) Sand in harmonic vibration. Owing to the lateness of the hour, Dr. Julien passed over the first two heads, giving an outline of the literature of the question of liquid films on solids. He then outlined his experiments in sonorizing sands artificially and in demonstrating the necessity of an antecedent water film before

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the sand becomes sonorous. The sand must also be of approximately uniform size of grain. The paper was discussed by Professors Mayer, Van Nardroff, Pupin and Hallock.

At 10:30 the meeting adjourned.

WILLIAM HALLOCK,
Secretary of Section.

STATED MEETING.

January 13th, 1896.

The Academy met with Dr. CURTIS in the chair, Dr. Dean acting as temporary secretary. There was an attendance of sixteen (16) persons.

In the absence of regular business, the Section proceeded at once to the reading of papers.

The first, that of Dr. Geo. S. Huntington on "Contributions on the Visceral Anatomy," dealt with the visceral anatomy of the following forms:

Myrmecaphaga jubata.
Tamandua bivittata.
Arctopithecus didactylus.
Dadypus sexcinctus.
Tatusia novemcincta.
Manis longicaudata.

In the brain (hemispheres) the uniform presence of a more or less modified longitudinal sagittal sulcus parallel with the great longitudinal fissure, the tendency to the formation of a transverse frontal sulcus, and the absence of a distinct Sylvian fissure, are to be noted as Edentate characters. In the alimentary tract the structure of the stomach separates sharply the Sloths from the remaining groups, being composite in the former, approaching the type of the sub-divisions found in Artiodactyla, simple in the others with a more or less well marked pyloric gizzard. The ileo-colic junction exhibits a complete series in

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the forms examined, from the simple ileo-colic transition of Manis to the complete cæcum of Tamandua.

Manis longicaudata: Ileo-colis transition direct, marked by bend or tube, caliber of large and small intestine uniform.

Cholœpus didactylus: Transition direct, caliber of colon larger.

Myrmecaphaga jubata: Transition direct, difference in caliber of colon and small intestine more marked.

Tatusia novemcinta: Transition direct, colon dilated uniformly, entrance of ileum central.

Dasypus sexcinctus: Rudimentary bilateral colic cæca, entrance of ileum central and intermediate.

Arctopithecus marmoratus: Rudimentary cæcum, entrance of ileum approaches lateral position, folds absent.

Tamandua bivittata: Cæcum and folds well developed, entrance of ileum lateral.

The arrangement of the blood vessels and the rudimentary ileo-cæcal folds in this series indicate the early condition of the mammalian cæcum as compared with the vascular and peritoneal arrangement of such forms as the Archoid group of carnivora, where the evidence points to the elimination of a former, cæcal, intestinal appendage, during the evolution of the group. The paper also considered the respiratory and genito-urinary tracts of *Arctopithecus marmoratus.*

The second paper was by Dr. O. S. Strong on "The Use of Formalin in Injecting Media." The writer pointed out the advantages of fixing whole brains by injecting in situ with formalin. Formalin (40 % formaldehyde) diluted with an equal volume of water is injected into the cephalic vessels until it runs from the cut jugulars. After a few minutes the same quantity is again injected, and once or twice again after an elapse of fifteen (15) to twenty (20) minutes. The brain is then removed and will be found to be completely fixed throughout. The swelling usually noticed in formalin hardened brains does not appear to take place when this method is employed. Besides

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the many general advantages of fixing brains by injection, formalin has the especial merit of giving them the best consistency for macroscopic work, and, further, such brains are available subsequently for the Golgi and Weigert methods, as well as, possibly, for cytological methods. Formalin also has the advantage that it can be used, as above, stronger than is necessary for fixation and thus allowance made for its dilution when permeating the tissue. When only the Golgi method is to be used an equal volume of a 10 % solution of potassium bichromate may be added to the formalin instead of water. Pieces can be subsequently removed, hardened further in formalin-bichromate and impregnated with silver.

The third paper was the following:

IS PALÆOSPONDYLUS A CYCLOSTOME?

BASHFORD DEAN.

Department of Biology, Columbia College.

Palæospondylus has seemed to fill the long-felt need of a Palæozoic Lamprey,—to assure the morphologist that the Marsipobranchs are in reality an ancient chordate stem, one of whose generalized members may in primæval times have given rise to the descent-line of the jaw- and paired-fin-bearing vertebrates;—to convince him that there is no direct need of regarding the Cyclostomes, as Dohrn and others had done, as the degenerate survivors of highly specialized forms, perhaps akin to the Teleosts. With the recent studies of Ayers, on the one hand, summarizing the strikingly primitive characters of Bdellostoma, and with the discovery of the Lower Devonian Palæospondylus, on the other, there seemed that at the present time it could not reasonably be doubted that the Lampreys were the descendants of a chordate stem both lowly and ancient.

The more recent studies on Palæospondylus, moreover, appeared fully to confirm the early suggestion of Traquair as to its Myxinoid characters. Its alliance with Marsipobranchs became, "more than probable (Smith Woodward)," "a tolerably close approximation to certainty (Traquair)," and further discoveries, when fossils should be found preserved in a matrix more compact than the Caithness flagstone, were looked to to prove, beyond a question, that its structural details were Marsi-

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pobranchian. The present writer, among the rest, had believed that Dr. Traquair had brought forward a more than strong case in his demonstration of the cyclostomian features of the fossil, and he was only too willing to accept so important an aid in the solving of the puzzle of the Lampreys. He has been, accordingly, not a little disconcerted to find in one of the specimens of Palæospondylus * in the collection of fossil fishes of Columbia College, some structural details which are decidedly opposed to the accepted view. And he must, therefore, believe that the question of the kinships of the Achanarras fossil is still far from being solved. The structures referred to appear to warrant the belief that paired fins may have been present, and that, on this account, Palæospondylus could not strictly have been a Marsipobranch.

The specimen in question, shown in the accompanying figure (See Plate V, Fig. B, at end of volume) is a small example, about 15 mm. in length, poorly preserved as to the caudal region, but showing favorably the structures of neck. It is here, as will be seen in the figure, that a dusky band may, on either side, be graced tailward from the region of the 'auditory capsules.' These bands, when examined with a glass, are found to resolve themselves into a series of ray-like structures, arranged transversely to the axis of the body, but slightly inclined backward. On the right side they are the more clearly seen, and are especially noteworthy in the region of the post-occipital (Traquair) plates, PO; here they appear in a graded series, RS, smaller in front, the largest one taking its origin from the position of the enlarged caudal end of the post-occipital. Seven or more can be counted; and each element is seen to become thicker distad, terminating bluntly. They cannot be said to definitely take their origin from post-occipital plates, although they certainly appear to, and there is a suggestion that the right occipital plate has been formed of metameral elements. The band of ray-like structures continues, however, caudad of the pectoral region, traceable backward to the region of about one-half the length of the vertebral axis. In this hinder region they cannot be distinctly followed, although they are clearly present, small in size, and but slightly enlarged distally. It might further be said that traces of fine ray-like structures have been noted at the side of the fossil near the pectoral region, but these at the best are so obscure that their presence cannot definitely be determined.

The exact character of these fin-like structures of Palæospondylus cannot, it is evident, be looked upon as entirely conclu-

* These had been received through the kindness of Mr. W. T. Kinnear, of Forss, by Thurso.

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sive from the evidence of this single fossil. But their presence is alone sufficient to cause us to review with some care the interpretations which have already been put upon the structures of the head and gill region of the fossil. Thus it is evident that if ray-like structures are present on the side of the body as far forward as the anterior end of the post-occipital plates, the "enlarged posterior part of the skull," which Dr. Traquair regards as "presumably composed of the combined parachordals and ear capsules," can no longer be looked upon as strictly a cranial region, but was rather the encasement of the branchial apparatus. And it would naturally follow that the capsules of the ear and eye would have to be sought in a more anterior situation, in the positions, perhaps, indicated in Traquair's figures in the "trabeculo-palatine part of the cranium" as *a*, *b* or *c*. The evidence that the ray-like structures were associated with lateral, rather than with vertical fins (as the present writer at first supposed) is by no means unsatisfactory. (1) The head and post-occipital plates of the fossil are arranged in perfect bilateral symmetry, showing that there was no torsion of these regions during petrifaction. (2) The ray-like structures of either side corrrespond to each other, and in their extreme anterior position find no analogue among the unpaired fins of existing fishes, even among the aberrent Heterosomes and Fierasfer. Negative as well as positive evidence, accordingly, indicates that these fin-like rays were concerned with the presence of paired fins. If this be true, is Palæospondylus to be regarded as a Marsipobranch? It is certain that the appearance of these fin-like structures must give weight to those characters of the fossil which have been adverse to its cyclostomian affinities, and must also tend to make more prominent the lack of precise knowledge as to its Myxinoid features. The evidence, favorable and unfavorable, might perhaps be summarized thus:

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MARSIPOBRANCHIAN CHARACTERS OF PALÆOSPONDYLUS.

	Positive.	Negative.
Tentacles of head.	Similar to those of the naso-mouth region of Bdellostoma, or even to the buccal cirrhi of Amphioxus Apparently as many as eleven or twelve were present.	Not necessarily marsipobranchian; mouth surrounding tentacles evolved independently in some of the larger groups of fishes, Sharks, and many Teleostomes, *e. g.*, Siluroids, Pogonias, Hemitripterus. Moreover it is possible that the "ventral cirrhi" are displaced structures from the cranial region, as one of the specimens examined by the present writer seems to indicate.
Jaw parts.	Unknown.	Unknown.
Cranium.	———	Chondrified, massive, filling the entire head, this with the huge auditory capsules, is far too large in size for any known Marsipobranch.
Vertebral column.	———	Highly specialized, massive centra, with differentiated neural arches, entirely un-cyclostomian.
Caudal fin.	Essentially marsipobranchian.	But its diphycercal (or perhaps heterocercal) condition also common to many groups, Shark, Lung-fish, Teleostome.
Paired fins.	———	Decidedly non-marsipobranchian: also the "post-occipital plates" which might well represent basalia of pectoral fins.

It will thus be seen that the only character which Palæospondylus retains allying it with the Cyclostomes is the presence of tentacles in the anterior head region, a strong ground of kinship be it admitted. But in view of the many un-marsipobranchian features, especially if the presence of paired fins be added, can the head-tentacles be taken to be in any way a crucial test of kinship? Or, on the other hand, would it not be more reasonable to believe that these structures, if they be a *ring* of tentacles, arose independently within the group to which Palæospondylus belongs?

The position of the fossil, if not to be regarded as marsipobranchian, is certainly undefinable. One is loth to accept the hy-

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pothesis of Sir J. W. Dawson* as to its larval characters on account of the presence of a well-defined vertebral column, and as to its rank as a specialized Stegocephal on account of its totally unamphibian fin-like structures. Perhaps one might most reasonably place it with the Ostracoderms among the curiously specialized offshoots of the early chordates, but this position would be at the best unsatisfactory. New material, however, may be awaited to demonstrate the details of its structures, and to enable a more satisfactory solution of the puzzles of its kinships.

Before adjournment Prof. Osborn proposed the name of Prof. C. Lloyd Morgan for corresponding membership. The nomination was duly referred to the Council.

A motion of Prof. Osborn was carried, appointing a special meeting of the Biological Section of the Academy for the evening of Friday, January 31st, the meeting to be similar to that held during the preceding winter, at which Dr. Poulton, Prof. Cope and others took part. It is proposed that Prof. Lloyd Morgan open the discussion of the evening on the subject, "The Origin of Instinct."

BASHFORD DEAN,
Secretary pro tem.

STATED MEETING.

January 20th, 1896.

The Academy met with Vice-President STEVENSON in the chair. There were about twenty (20) persons present.

The minutes of the previous meeting were read and approved.

Dr. J. Caumeight was nominated for resident member, and the nomination was referred to the Council.

The Section of Geology and Mineralogy then organized.

The first paper of the evening was by E. O. Hovey, on "The New Discoveries of Rare Minerals on Fort Washington Avenue and the New Speedway." Dr. Hovey exhibited a very large crystal of tourmaline, about 9½ inches long and 4 inches in diameter; and also some unusually large specimens of xeno-

* *The Salient Points in the Science of the Earth.* London, 1893, pp. 285, 286.

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time and monazite, and mentioned many others that had been found in association with these. The paper was discussed by the Secretary. It appears in full in the *Bulletin of the American Museum of Natural History*, Vol. VII., 341, November, 1895.

The second paper of the evening was by J. F. Kemp and T. G. White, entitled "Additional Notes on the Petrography and Distribution of Trap Dikes in the Region of Lake Champlain." The paper appears in full later in this volume.

The third paper was by W. D. Matthew, on "The Metamorphism of Triassic Coals by Diabase Dikes at Egypt, N. C." It is to be found on a subsequent page.

The last paper was by J. J. Stevenson, on "The Cerillos Coal Fields near Santa Fé, N. M." The paper is printed below.

The Academy then adjourned.

J. F. KEMP,
Recording Secretary.

THE CERRILLOS COAL FIELD.

BY JOHN J. STEVENSON.

CONTENTS.

PAGE.
Introduction 106
Geological structure of the area 107
The Eruptive Rocks 108
The Laramie 110
The White Ash coal bed 111
Boyle mine 111
Lucas mine 113
Cunningham mine 113
White Ash mine 114
The "Coking Seam" 115
The Cook-White coal bed 116
Characteristics of the Coals 117
Chemical composition of the White Ash bed 117
Chemical composition of the Cook-White bed 119
Cause of the Metamorphism of the Coal 120
Prof. Kemp's Notes on the Eruptive Rocks 121

The Rio Galisteo rises in east central New Mexico and flows westward to the Rio Grande. Its bed is on the Dakota, Colorado and Montana, but the streams from the south drain the

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Laramie area known for many years as the Placer coal field. Its basin lies south from the Spanish ranges, the last continuous portion of the Rocky Mountains. The Placer Mountains, consisting largely of eruptive rocks, are about 25 or 30 miles south from Sante Fé, and the patch of Laramie bordering upon them is probably only a detached portion of the area extending southward for a long distance. Other "lost mountains" apparently similar in character to the Placer are seen on the borders of that area further south.

The Placer Mountains were so named because the auriferous gravels on their northern side have been worked in a small way by the Mexicans. The water supply is so insignificant that despite the extraordinary richness of the gravels the amount of gold obtained has been little more than sufficient during many years for the Sante Fé jewelers. Latterly, the Laramie coals have been mined very extensively and new names have been applied to the more prominent localities, so that the Placers are now the Ortiz Mountains, and the Placer coals are in the Cerrillos coal field, the latter appellation being taken from petty hills beyond the Galisteo, containing the celebrated turquoise mine, which was worked for centuries by the Pueblo Indians.

The Galisteo area possesses much interest because of the singular diversity of opinion existing among those who have studied the region. Marcou, Newberry, Le Conte, Hayden, Cope and Stevenson published notices bearing especially upon the relations of beds underlying the Laramie. Newberry and Stevenson described the Laramie beds, though only after reconnaissance fashion; both of these writers recognized the transition from bituminous to anthracite coal in a single bed and found the cause in a great dike following the face of the Placer or Ortiz Mountains.

During August of this year the writer had an opportunity to spend a few days in studying a small portion of the Laramie area—that controlled by the Cerrillos Coal Company. This, lying southward from Waldo and Cerrillos (stations on the Atchison, Topeka and Santa Fé Railroad), is barely a mile and a half wide from east to west and somewhat more than four miles long from north to south. Its eastern boundary is Ortiz or William's Spring cañon. About half a mile west is Coal cañon, which reaches further south and is somewhat deeper than the other. The space between the two cañons, in the area especially under consideration, is irregular, being cut by shallow, longitudinal gorges opening at the north into a rapidly deepening channel-way, which begins almost on the brow of Coal cañon and leads to Ortiz. Further northward, a mesa continues

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for a little distance but thence the surface becomes irregular and broken. Southwardly, the surface rises to the Ortiz mountains.

Waldo station, where are the coke works of the Cerrillos Coal Company, is at the mouth of Coal cañon; two miles above it, in the cañon, is the village of Madrid, where one finds the Company's offices.

This area shows apparently all the workable coal beds of the Laramie, and probably contains the greater part, if not practically all of the anthracite. It exhibits the gradations from bituminous to anthracite as well as some phenomena in structure, familiar enough elsewhere, but previously unrecognized here. The student now finds better opportunities for investigation than did the geologists already named, as the mining operations have become extensive, and definite opinions can be reached concerning matters respecting which, under other conditions, only conjectures could be offered.

Several mines have been opened in Coal cañon, the most important being in the immediate vicinity of Madrid; the Lucas, at the southerly end; the Cunningham, at the village, and the White Ash, immediately north from it. These are all on the upper or White Ash bed; two mines on the lower or Cook-White beds are within the village limits but are not worked.*

Geological Structure of the Area.

No anticline occurs and the dip is almost east, N. 85° E., but on Coal cañon, at about a third of a mile below the White Ash mine, the beds show very rapid northward dip for half a mile. Ordinarily the rate does not exceed 15° or 16°, but occasionally for a short distance it is much greater.

No rocks older than the Laramie occur anywhere within the area under consideration except near Galisteo River, where beds of the Fort Pierre stage are reached. But great masses of trachyte, both as dykes and as intrusive sheets, form a characteristic feature of the anthracite area and extend to half a mile or more toward the west.

The Eruptive Rocks.—The most southerly point visited is on Coal cañon at probably four miles above its mouth, where one of the thinner coal beds was coked six or seven years ago. There, as clearly enough for a mile further up the canon, the easterly wall is capped by trachyte, 50 to 100 feet thick on the edge of

* The writer is under many obligations to Mr. James Duggan, Superintendent, and Mr. Porterfield, Engineer of the Coal Company, for information which otherwise he could not have obtained. Mr. Charles J. Devlin, General Manager of Coal Properties of the Atchison, Topeka and Santa Fé Railroad Company, courteously furnished copies of the analyses of the coals.

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the mesa, but increasing rapidly in the side cañons, where it has suffered less from erosion. Further down, especially near Madrid, irregular erosion of the wall shows that this sheet dips with the stratified rocks. Its northern limit is at the road leading from Madrid to Ortiz cañon, whence northward the mesa is lower. Following that road beyond its summit, which is at the westerly edge of the mesa, one finds an unbroken mass of the trachyte south of the road, extending almost to Ortiz cañon and apparently continuous southward to the Ortiz Mountains, all overlying beds having been removed by erosion. As far as could be ascertained, only a narrow dyke-like strip, not more than 70 feet wide, extends northward beyond the road and terminates near the bluff overlooking the White Ash pit. The mass south from the road is interrupted in a petty cañon and in like manner by Ortiz cañon itself, Laramie rocks being exposed in both. It is certainly thinner in these cañons, for coal beds are shown in the former at several yards higher than an exposure of the trachyte little more than 100 yards further west. There seems to be good reason for believing that the sheet broke across the strata near Ortiz cañon so as to rest on higher beds there than in Coal cañon.

Erosion has cut this sheet into long strips between Coal and Ortiz cañons so as to make it resemble a series of dikes—a resemblance increased by the abrupt change in course at a little way west from Ortiz cañon. But the slopes of the White Ash and Lucas mines have passed underneath this mass, the former, now 3100 feet long, extending to within a few feet of Ortiz cañon, and, therefore, practically beyond the limit of the sheet.

A very distinct dike, 4 feet wide, was seen in a little side cañon just below the old Boyle mine on Coal cañon. It passes directly into the overlying mass, but its northward extent could not be ascertained. Another, fully 12 feet wide, is shown at Madrid, near the Company's store; it passes through the village and soon becomes a conspicuous feature northward, along the westerly side of Coal cañon. These are distinctly dikes, with the stratified rocks in direct contact on both sides; but they are evidently branches from a deeper sheet, which does not come to the surface along Coal cañon. The broader dike does not reach to the upper sheet near Madrid, for it has not been crossed in the Lucas mine.

Two years ago the coal company drilled a hole, beginning on the mesa west from Coal cañon. The lower sheet of trachyte was reached at about 200 feet from the surface and proved to be almost 200 feet thick. It outcrops in a shallow cañon at the west, along which it can be traced southward into rugged hills

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rising some hundreds of feet above the mesa. On the road from Madrid, and considerably south from the bore-hole, this rock is crossed in an arroye at a higher elevation than in the hole, so that there it has burst through the stratified rocks to form a dike which is continuous with the hills already referred to.

The lower sheet extends northward further than does the upper, but disappears before the northern face of the mesa has been reached, for no traces of it were seen along the road or along that face, where the exposures are very distinct. The thinning out and abrupt termination of this sheet have caused the rapid and abnormal northward dip shown in Coal cañon and in the northerly levels of the White Ash mine at half a mile from the crop, where it is very annoying.

As already stated, the appearance of these sheets at more than one locality is precisely that of typical dikes, but there is no possible dispute respecting the intrusive character of the upper sheet, still more than 150 feet thick in places, for the slopes of mines on the White Ash bed have passed underneath it to its eastern limit without crossing any eruptive rock whatever; and the lower sheet is equally proved, for in the bore-hole the *Waldo coal bed* occurs, with the *Miller's Gulch coal bed*, at the proper distance below, increased by the thickness of the trachyte. The structure in this coal field is extremely like that in the Anthracite range of Colorado, as described by Dr. Cross;* the Ortiz Mountains being the main mass whence extended the sheets, which may have been joined by dikes filling fissures formed during the intrusion of lava.

The region further south, where gold mining has been carried on for many years in a very small way, has always been regarded as badly cut up by-dikes. In the Cerrillos coal fields the expected amount of coal was small because of the enormous dikes, while in the gold field boring for water was thought to be useless for the same reason. But the dikes have proved to be sheets in the Cerrillos region and there is good reason for supposing that they are sheets in the gold field, for several holes drilled in 1895 have yielded a good supply of water.†

The Laramie Rocks.—The Laramie or highest stage of the Rocky Mountain Cretaceous is represented by light yellowish to gray sandstones and gray to black shales. For the most part the sandstones are deficient in cementing matter and weather readily, the thicker beds showing a cavernous surface at the outcrop and their fragments assuming a spherical or oval shape.

* Whitman Cross. The laccolitic mountains groups of Colorado, Utah and Arizona. In the 14th Ann. Rep. of U. S. G. S., pp. 157-241. Fig. 31, p. 187.

† For description of the rocks, see notes by Prof. J. F. Kemp, appended to this paper.

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Occasionally the thinner beds or those less massive are harder and sometimes, though rarely, a bed of comparatively hard rock is found which answers for building in a region where the rainfall is not great and the chief enemy to durability is the extreme range of temperature. The proportion of shale is greater than at more northern localities and short sections are similar to those obtained in the coal measures of Ohio and western Pennsylvania. As in the Rocky Mountain areas, limestone is apparently wanting, no bed having been seen.

The regular dip, the persistence of the sandstones and the absence of vegetation make exposures numerous and continuous along the cañons. At the same time the entire absence of limestones and the notable similarity of the sandstones render the making of a general section somewhat difficult, for no means is available except that of direct tracing, which is often perplexing in passing from one cañon to another. The sandstones for the most part appear to be non-fossiliferous, the only distinct impression being that of a cypress in a sandstone above the *White Ash coal bed.* The highest sandstone of the section, which, however, is evidently far from being the highest bed in the field, contains abundance of silicified wood at about half a mile north of east from Madrid.

The coal beds are very numerous, there being nine within 77 feet below the *White Ash* seam, but only one of those is more than a foot thick, and several of them are not persistent in all of the sections. The very considerable thickness of shale and the extensive deposits of sandy clay overlying several of the beds suggest that the depression after the bed was formed must have been gradual and that this area must have been at a considerable distance from the even slightly elevated mainland at the north.

It is unnecessary at this time to give detailed sections, as this paper is merely preliminary * and has for its purpose only the presentation of such facts as bear upon the condition of certain coal beds. The essential features are given in the folllowing section, the unimportant coal beds being omitted:

1. Sandstones and shales .....250′
2. *White Ash coal bed* .....2′ 6″ to 7′
3. Sandstones, shales and thin coal beds ..... 70′
4. *Coal bed*, coking..... .....1′ to 2′ 6″
5. Sandstones, shale and thin coal beds..... 40′
6. *Coal bed* and shale.. .....2′ to 6′

*A sudden illness brought the writer's studies to an end before the work was finished and the imperfect results are presented only because, as far as they go, they appear to possess some interest.

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7. Sandstone and shale..... 40′
8. *Cook-White coal bed*..... 3′
9. Sandstone, shale and thin coal beds, about 150′
10. *Waldo coal bed*..... 4′
11. Sandstone, shale and thin coal beds .....250′
12. *Miller's Gulch coal bed* ..... 3′
13. Sandstone, shale and thin coal beds .....200′
14. Fort Pierre shales.....

The Fox Hills stage of the Rocky Mountain region is not represented in this area.

The sandstone at the top of the section is shown on a triangular hill in Coal cañon half a mile below the *White Ash* mine. It is comparatively fine-grained, soft, yellow; evidently the same sandstone is shown near Ortiz cañon, where it contains silicified trunks of trees. Some of the fragments which have weathered out are of large size, one having been seen which is about 2′ thick and 3 feet long. This silicified wood is by no means so beautiful as that seen in some portions of California and Nevada, or even as that from the Chalcedony Park, of Arizona, but the replacement is complete and the structure of the wood is distinct in many of the specimens. This sandstone passes below higher beds at the east, just beyond Ortiz cañon.

The White Ash coal bed, known as the *Boyle, Lucas or White Ash vein*, is the important bed of the Cerrillos district and the only one now worked to any extent. It outcrops on the easterly side of Coal cañon, where it was examined from about two miles above Madrid to its disappearance below the surface at about a mile below that village. It was opened long ago at several places and the coal was carted several miles to the nearest railway station.

The *Boyle mine*, about a mile and a half above Madrid, the most extensive of the old openings, is, like the other old pits, almost shut and the coal cannot be reached, but fragments on the dump show that the coal is anthracite. Another opening was seen in a small side cañon, less than a quarter of a mile further down, which shows

Coal.....1′ 2″
Clay .....1′ 3″
Coal .....2′ 3″
Coaly shale.....0′ 5″

The distance to the bottom of the upper trachyte sheet is about 50 feet, but the upper 35 feet of the interval is concealed; at the Boyle mine it is barely 10 feet and on the op-

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posite side of the little cañon it is less than 20 feet with the contact concealed. The coal is roofed by 1 foot 7 inches of laminated shale, black at the bottom, with 7 feet 6 inches of clay and 6 feet of sandstone above.

The upper division of the coal is evidently the "rider" coal of openings further down. The lower division shows no distinct partings but has a streak of "bone," sometimes 6 inches thick but very irregular and often absent. The coal varies much but is anthracite in both divisions. For the most part, it compares well with any from Pennsylvania, though the lustre is less brilliant, but some portions are rudely prismatic and have a grayish black tint not unlike that of the Rhode Island graphitic anthracite. The coal is jointed and slipped throughout and in many portions the surfaces of fracture resemble those of Kentucky birdseye cannel.

The coaly shale below rests on shaly clay which passes gradually into impure fireclay.

Numerous pits have been opened further down the cañon, but no systematic mining has been done above Madrid, where one comes to the Lucas mine. A fine breaker with a daily capacity of 800 tons has been erected there at the terminus of a branch railway from Waldo station, about two miles distant on the Atchison, Topeka and Santa Fé railway.

The section exposed along the tramway leading from the mine to the breaker is

1.	Debris	10′
2.	*White Ash coal bed*	2′ 6″
3.	Clay shale	8′
4.	*Coal*	4″– 5″
5.	Sandstone and shale	6′
6.	Shale	8″
7.	*Coal*	2″
8.	Clay and shale	3′
9.	*Coal*	8″–10″
10.	Black shale or clay	1′ 8″
11.	Sandstone, seen	3′

The "rider" coal bed seen near the Boyle mine at only 1′ 3″ above the main seam is represented here by an irregular seam, several, sometimes 6 feet above, the interval being filled with clay, which forms the roof in this mine—a roof which would be regarded as very insecure in a moist climate, but which proves a source of very little anxiety in this arid spot, to which all the water consumed must be brought by rail. The *White Ash coal* is from 2′ 4″ to 2′ 7″ thick near the mouth of the slope, but

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within the mine it sometimes becomes 4 feet, though seldom exceeding 3 feet. The Sandstone, No. 11, is an insignificant feature here and for some distance beyond, but below the White Ash mine it becomes a well-marked horizon.

The slope in the Lucas mine is somewhat more than 1,000 feet long toward the south of east and levels have been set off both right and left at distances of approximately 100 feet, so that a large amount of coal has been removed. The bed dips regularly almost toward the east and the fall along the slope is about 26 feet per hundred.

The coal as seen in the breaker gives evidence of having been subjected to great pressure; some portions have been so crushed and rolled that the coal is laminated as much as that from some Vespertine localities in Virginia, and the polished surfaces, often curved, are frequently not more than one-fourth of an inch apart. Yet the fragments have been so consolidated as to bear handling fairly well and to yield in the breaker a large proportion of marketable coal. Other portions, yielding less waste, show equally well the effect of movement and consequent crushing, for they are jointed in two systems and often break into rhomboidal prisms. In still other portions the influence of disturbance is not shown, for large specimens with conchoidal fracture like that of the Pennsylvania anthracite exhibit the type. The bed contains some "bone" at this mine, but the thickness is unimportant and its distribution very irregular.

The most profitable coal is found in the 1st and 2d levels south; that in the 3d and 4th is of excellent quality, but somewhat inferior to the other; in the other southerly levels the coal becomes less and less good, so that at the end of the slope, about 1,000 feet from the crop, the quality is quite inferior. The northerly levels all reach coal so tender as to be unprofitable; the southerly boundary of the tender coal approaches the slope, so that it is reached in the 4th level north at only 400 feet.

The *Cunningham mine*, at the lower end of the village of Madrid is about 1,100 feet long. It entered tender coal almost at once and its first level southerly was carried to within about 500 feet of the first northerly level of the Lucas.

The *White Ash mine*, below Madrid, and the most extensive in this region, was opened and much coal taken from it before the present company secured control of the territory. At the time of examination the slope had been driven 3,100 feet and its face was almost under Ortiz cañon, being practically at the angle between that cañon and the irregular ravine followed by the road from Madrid. Two "rider coals" within twelve feet

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above the main coal were exposed in this mine by a fall of the roof.

The dip is from 10 to 12 degrees, the slope being off the line of greatest dip, but in the 5th level, northerly, an abrupt change to 45 degrees was found, which continued for but a short distance. Only two faults have been encountered, the larger one having a throw of 17′. The most serious trouble is on the northerly side, where a great sandstone "horseback" several hundred feet long and at one place 75 feet wide replaces the coal. The bed is from 4 to 7 feet thick.

The coal varies as in the Lucas mine. The best is hard, makes but little dirt, burns freely and has about 39 per cent. of volatile combustible, yielding by actual test about 10,000 cubic feet of gas per ton. It shows abundant evidence of crushing and disturbance, but bears handling well and for the most part the "run of mine" is shipped. But another grade occurs, in quantity sufficient to cause serious annoyance and loss. It is the "soft" coal to which reference has been made already. It is dull, sometimes slightly granular in appearance, is so tender that it can be crushed between the fingers. Most fragments exhibit on the smoother surfaces a typical cone-in-cone structure, with occasionally a suggestion of wrinkling, such as is shown by Siberian graphite. The friability is such that no use has been found for this coal and it is thrown on the dump as waste.

The marketable coal is obtained for the most part from the northerly levels; the tender coal is reached in the first level south at 800 feet from the slope and it has been followed thence for 1,300 feet into the old Cunningham mine, where, as already stated, it prevails to the end of southerly levels or to within about 500 feet of the first level, north of the Lucas mine. This level has been in the tender coal for 150 feet, so that the north and south face of the unmarketable coal is more than 3,000 feet along Coal cañon. The slopes of the White Ash and Lucas mines are approximately parallel, the amount of divergence being unimportant in this connection. The southern boundary of tender coal in the Lucas mine approaches the slope; the northerly boundary of the tender coal approaches in like manner the slope of the White Ash, so that the end of the slope in each mine had reached inferior coal at the time of my visit. But it is very certain that not all of the area within these limits is occupied by inferior coal, for in the White Ash, sixth level north, the poor coal, reached at 125 feet from the slope, was but 325 feet wide and passed into excellent anthracite, which was followed for 125 feet.

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The passage from bituminous coal to anthracite is through this crushed coal and is gradual. According to the statement of Mr. Porterfield, the coal company's engineer, the change from crushed to anthracite is completed within 50 feet as shown in the sixth level. The anthracite comes in at the bottom and thickens gradually, the crushed coal being replaced by the laminated and that by harder, almost homogeneous coal showing little trace of disturbance.

Several abandoned openings were seen below the White Ash mine. The Greene slope was stopped at 1,100 feet because the coal pinched out, and another, just beyond, was stopped at 250 feet for the same reason. This disappearance of the coal may be connected with the great "trouble" already mentioned as occurring in the White Ash. At this last opening begins the very rapid northward and northeastward dip already mentioned as due to the disappearance of the lower trachyte sheet. Several trial pits expose the coal as it descends quickly toward the floor of the cañon, where it is last shown at the bottom of a hill, opposite the point of a spur from the west side, at perhaps half a mile below the White Ash mine.

There remain to be noticed in connection with this bed only the old openings in a narrow irregular cañon immediately west from Ortiz (William's Springs) cañon. The section is

1. Shale and clay	8′–10′		
2. *Coal*	2′ 8″		
Shale	3″		
Coal	11″	3′ 10″	
3. Shale		2″	
4. *Coaly* shale or shaly *Coal*		10″	4′ 10″

The coal is distinctly anthracitic and it was mined years ago to be carried in wagons to Cerrillos station. The place of this bed was not determined satisfactorily, as the little cañon is almost cut off by the trachyte overflow. It seems to be higher than the *White Ash*, but its dip should carry it far below the surface at the junction with Ortiz cañon and so bring very near to that bed.

The *Coal bed*, No. 4, the *Coking seam*, is from 1′ 6″ to 2′ thick and is roofed by 6 feet of drab clay, on which rests a 6-inch streak of coal. It was mined years ago at 2 miles or more above Madrid, where it yielded a good coal, which was coked in ricks upon the ground. The ricks were numerous and several hundreds of tons of coke must have been made. Fragments lying on the ground show that the quality was far from being inferior. The interest attaching to this bed is in the fact that

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at not more than 70 feet higher is the hard anthracite of the *White Ash*, and at more than 80 feet lower is the *Cook-White bed*, whose coal, if not anthracite, is certainly much changed. A trial pit was seen in this bed near the Boyle mine, but it had fallen shut. This may be the bed opened on the west side of the cañon at somewhat less than half a mile below the White Ash mine.

The Cook-White or *Red Ash coal bed*, No. 8 of the section, is not worked at present. Its outcrop is shown on the east side of Coal cañon from a short distance below the White Ash mine to somewhat more than a mile above Madrid; but below the Boyle mine the floor of the cañon begins to rise so rapidly that there is no reason to suppose that the bed will be reached again in that direction, and its outcrop must be sought further west.

An imperfect exposure at about a mile and a quarter from Madrid shows:

Coal	6″
Coaly shale	5″
Coal	8″

with the bottom not reached. Another old pit somewhat further down shows a slight difference:

Coal	10″
Clay	4″
Coal	1′ 6″

and the bottom is not shown. An opening near the ball-ground has fallen shut, but fragments on the dump as well as on the dump of another old pit near the railroad tank-house show that the coal has undergone material change and that much of it is anthracitic. A pit, now closed, behind the company's store at Madrid is said to have yielded some natural coke, which is by no means improbable as the dyke, so conspicuous farther down the cañon, passes very near the mouth. An old pit, directly under the mouth of the Cunningham mine, shows:

1. Shales	9′
2. *Coal*	0′ 6″
3. Black shale	1′ 3″
4. Clay	4′
5. *Coal*, seen	2′ 6″

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the dip being 15 degrees almost due east. No work has been done here for a long time, but in the early summer of 1895 a shipment was made from another opening at the lower end of Madrid. This coal is very tender, such as hardly to bear handling, and in many ways resembles the more tender portions of the *Pocahontas coal*; but it is much less friable than the poorer varieties of the *White Ash*. The latter have apparently little value as steam producers, the flame being drawn away from the coal as soon as the draught is put on; but the *Cook-White coal*, as tested by a late shipment, proves to be excellent as a steam producer. The purchaser imagined from its appearance that it would be a good gas coal, but when tested it is said to have yielded but 2,000 feet per ton, equivalent to about 8 per cent. of volatile; this, however, does not accord with the results of analysis as given later on.

The last exposure seen is in the long side cut on the railroad below the White Ash mine, where the bed is 2′ 8″ thick and single. Its coal appears to be bituminous, but the crop is so decomposed that any positive statement respecting its character cannot be given. The bed passes below the surface at a short distance beyond this exposure.

Characteristics of the Coals.

The most interesting feature of this region is the distinct transition of bituminous coal into anthracite as exhibited in a single bed. At one time wagons carrying bituminous coal, others carrying semi-bituminous and still others loaded with anthracite, could be seen in the same train as it was hauled out of the White Ash mine.

The composition of the best bituminous coal, that obtained in the northerly levels of the White Ash mine, is shown by the following analysis (W. D. Church.)

Water	2.00
Volatile Matter	39.00
Fixed Carbon	53.76
Ash	5.24
Total	100.00
Coke	59.00
Sulphur	0.032

The coke is strong and tough. The same chemist gives the following as the composition of the ash:

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Silica	26.93
Alumina	32.41
Oxide of iron	3.96
Calcium oxide	24.68
Magnesium oxide	10.32
Calcium sulphate	0.21
Alkalies and loss	1.49
Total	100.00

The calcium oxide is derived from calcium carbonate, which appears as stains and occasionally as crystalline plates along the cleavage. The color of the ash is light yellowish gray; phosphorus is only 0.006; and the specific gravity of the coal is 1.410.

The composition of an average sample of the anthracite embracing nut, stove and egg sizes, taken from the bins at Topeka, is (W. D. Church).

Water	0.16
Volatile matter	1.04
Fixed Carbon	93.02
Ash	5.78
Total	100.00
Sulphur	0.117

The ash consists of

Silica	32.14
Alumina	36.58
Oxide of Iron	12.85
Calcium oxide	8.19
Magnesium oxide	5.11
Calcium sulphate	0.18
Sodium oxide	1.38
Potassium oxide	3.59
Total	100.00
Phosphorus	0.0033

The color of the ash is given as reddish ochre. The specific gravity varies from 1.537 to 1.540.

These analyses show some curious variations in composition of the ash, there being a very notable increase in the proportions of silica, alumina, oxide of iron as well as of alkalies, while there is a very striking decrease in calcium and magnesium compounds. The volatile matter has been removed, yet the ash remains practically the same. These variations are not easily

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explained, unless we regard the coal as originally different in composition at the White Ash and Lucas localities, since the anthracite owes its origin not to longer continuance of the process of conversion from vegetable to coal, but to the prompt action of heat causing metamorphism.

The distance between good bituminous coal and good anthracite is little more than 2,000 feet along the strike; but it must be remembered that the anthracitic character is not lost abruptly in the northerly levels of the Lucas mine; the change takes place gradually, so that even where the mining ceased at 500 feet north from the slope much of the coal is very good. Mining was stopped because the coal is so much broken as to be wasted in the breaker. It should be remembered also that the space between the White Ash and Lucas contains some anthracite of the best quality, as was proved in the sixth level, south of the former mine. At the same time there is every reason to believe that a very great portion of the space between the two mines is occupied by the "tender" coal, showing gradual transition from anthracite to bituminous.

The Cook-White bed, about 150 feet below the *White Ash*, shows a similar change in character, though analyses have not been made of the different grades. Fragments on the dumps of old openings south from Madrid shows that the coal is anthracite. At the lower end of Madrid, about midway between the Lucas and White Ash mines and almost directly under the entrance to the Cunningham mine, the coal of the lower bed is tender, but less so than that from the upper bed, even in the Cunningham. An analysis of coal from this mine by W. D. Church gives its composition as

Water	1.10
Volatile Matter	30.20
Fixed Carbon	60.94
Ash	7.76
Total	100.00

which shows that it contains much less volatile than the White Ash at a little way farther north. The results of this analysis do not agree with those of a test of two carloads. The coal was supposed from its appearance to be rich in gas, but the trial is reported to have shown a yield of only 2,000 cubic feet per ton. As *White Ash* coal yields about 10,000 cubic feet of gas per ton, it would appear that the *Cook-White* coal from this pit should average not more than eight per cent. of volatile.

No analyses of this coal have been made from any locality

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lower down the cañon and none of the pits seen is in condition to give samples fit for analysis. But this bed should yield bituminous coal near the White Ash mine if the change toward the normal condition continue northward. An opening in Madrid is reported to have yielded some natural coke near its mouth.

The *thin coal beds* above the middle of the interval between the principal beds are bituminous and show no evidence of change, even at two miles or more above the Lucas mine, where they yielded excellent coal for coke. These beds are badly cut by clay seams, the coal being replaced at times for several feet. Such complete replacement of the coal occurs very rarely in the White Ash and is unknown in the more southerly mines.

Cause of the Metamorphism of the Coal.

As already stated, both Dr. Newberry and the writer found the cause of metamorphosis in heat of eruptive rock in contact with the coal. The observations recorded in this paper seem to confirm that opinion, which, when first presented, was rather a suggestion than a conclusion, the facts being known imperfectly. The centre of eruption being in the Ortiz mountains, only two or three miles south from the area examined, the metamorphism ought to be more marked as that centre is approached. That is distinctly the condition, for at the most southerly pit showing the coal well, the anthracite is very hard and in part resembles the Rhode Island coal; but the change is less and less toward the north until normal coal is reached in the White Ash mine below Madrid.

The gradation is equally clear in the coal of the *Cook-White*, but the small beds between the main seams appear to contradict the hypothesis, as they are decidedly bituminous at half a mile beyond the locality where the *White Ash* yields the hardest anthracite. This condition, however, may be explained by the fact that the beds are not continuous; the clay seams would prevent the passage of heat from one portion to another.

The conditions at several localities show that mere proximity to a mass of eruptive rock is insufficient to produce any material change in the coal. The lower plate is only 8 to 10 feet below the *Waldo coal bed* in the bore hole west from Coal cañon, but, though 200 feet thick, it has had no appreciable effect upon the coal. The interval between the *White Ash bed* and the upper plate shows insignificant variations along the mesa front in Coal cañon, and the interval must be approximately the same in the newer portions of the White Ash mine; yet in the Lucas

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mine and all points examined south from it the coal is anthracite; whereas at all points north from it to the border of the eruptive rock one finds only transition coal.

Direct contact appears essential to change. The occurrence of anthracite in the 6th level south of the White Ash mine suggests that the upper plate comes down to the coal for a short distance before changing its course into higher beds of the section, or possibly that a dike exists there like that in the upper part of Coal cañon. If direct contact be necessary there is no difficulty in explaining the decreasing extent of change observed in the coal as one follows it from the centre of eruption.

The cause of the crushed or friable coal is not far to seek, the limits of that material being fairly well defined. It is found near the border of the upper plate, in the space where the influence of the metamorphosing agent is becoming markedly less. Undoubtedly the intrusion of the trachyte plates, each not far from 200 feet thick, caused crushing of the coal at all points as far north as the edge of the upper plate, but the effect appears to be more and more marked as one passes northward from the Lucas mine; for the anthracite soon shows a foliated structure in spite of the change in composition. Further down where the thickness of the upper plate becomes less and the compressing power above consequently less, the slipping and crushing due to the intrusion of the lower plate would become more effective. But beyond the limits of that plate there was only the uplifting influence of the lower, and the coal is not crushed sufficiently to injure it for commerical purposes, though the effect of the certainly somewhat abrupt displacement is distinct in the many slickensides shown in all parts of the White Ash mine.

Prof. J. F. Kemp describes the eruptive rock as a trachyte closely allied to andesite; so that its outflow was early, possibly at the time of the Laramide elevation, when great outpourings of andesite occurred in Colorado, Utah, Wyoming and Montana. It may be true also that these intrusions were prior to the folding of the beds, though the fact that the sheets follow closely planes between the strata is not necessarily decisive upon this point. The feature of especial interest is that the coal was completely formed when the disturbance took place, there being not only no evidence of pulpiness but every evidence that the coal was hard. It was crushed into minute fragments, slickensided like the Utica shales of Franklin county, Pa., or laminated like the Vespertine coals of southwestern Virginia. It seems, therefore, reasonably certain that the process of conversion was complete before this disturbance began; complete not only in the lower beds, but also in the *White Ash*, at nearly 900 feet above the bottom of the Laramie.

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Heat from crushing and folding did not produce the metamorphosis. The slickensided coal of the *White Ash* mine has almost 40 per cent. of volatile; the "*Coking seam*" in the upper part of Coal cañon is decidedly bituminous, though the White Ash, higher up the hill is an almost graphitoid anthracite.

The facts appear to point to but one conclusion—that the coal was changed into anthracite solely by contact of the beds with the enormous mass of eruptives.

NOTE.—The specimens of eruptive rock obtained near Madrid were submitted to Prof. J. F. Kemp, who has furnished the following results of his examination.

1. *Mesa, Coal Cañon.* Markedly porphyritic rock. Phenocrysts, orthoclase in excess, plagioclase much rarer; hornblende abundant, augite much rarer. The groundmass is both finely crystalline and glassy. The orthoclase phenocrysts are zonal, and generally of six-sided cross-section with extinction parallel to one of the sides. The rock is a trachyte and has the texture of a surface flow.

2. *Dike near Boyle's Mine, Coal cañon.*—Markedly porphyritic. Phenocrysts of orthoclase and plagioclase, former in excess; hornblende abundant, augite much rarer; occasional quartz. Some small shreds of augite and hornblende; magnetite and titanite. The rock is a trachyte and has a texture not differing essentially from a surface flow.

3. *Mesa above White Ash Mine.*—Markedly porphyritic. Phenocrysts of both orthoclase and plagioclase, but both show strains and undulatory extinctions. Much green hornblende, comparatively little augite, titanite, magnetite; finely crystalline groundmass containing some glass. The rock is a trachyte and has the texture of a surface flow.

4. *Dike below the White Ash Mine.*—Porphyritic structure poorly, if at all developed. The rock is holocrystalline. The feldspars are much the most abundant minerals and orthoclase is more common than plagioclase. Augite is abundant in well bounded crystals and surpasses hornblende in amount. Parallel growths of the two occur. Magnetite and titanite are present. The rock is a dike or deeper seated phase of the others and to this owes its tendency to a granitoid structure.

I should think that all four specimens were derived from the same igneous magma and eruption, and that the mineralogical variations and the difference between the texture of the last and those of the others were not sufficient to make them worthy of different names. They are all trachytes with close affinities for andesites. No. 3 in particular is strongly andesitic.

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Public Lecture.

January 27th, 1896.

The second public lecture in the course of 1895–96 was delivered by Prof. R. E. Dodge, of the Teacher's College, on "The Physical Geography of New York City and Neighborhood." The lecturer illustrated his remarks with an extensive series of lantern views and was attentively listened to by about fifty persons.

At the conclusion of the lecture a vote of thanks was extended the lecturer.

J. F. Kemp,
Secretary.

Extra Meeting of the Biological Section.

January 31st, 1896.

An extra meeting of the Biological Section of the Academy was held on the evening of January 31st, in Hamilton Hall, Columbia College.

The object of the meeting was to hold a symposium and discussion on the "The Origin of Instinct."

The discussion was opened by Prof. C. Lloyd Morgan, of Bristol, England. It was participated in by Prof. J. Mark Baldwin, of Princeton University, Prof. J. McK. Cattell and Prof. H. F. Osborn, both of Columbia University, and others.

Nearly 100 persons were present.

J. F. Kemp.
Secretary.

Regular Business Meeting.

February 3d, 1896.

The Regular Business Meeting of the Academy was held on February 3, 1896, at Hamilton Hall, Columbia College. President J. K. Rees in the chair. Fifteen persons present.

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The minutes of the last meeting were read and approved.

The Secretary reported from the Council that the following persons were recommended as resident members:

Dr. Franz Boas, Anthropologist of the American Museum of Natural History.
Prof. Nicholas Murray Butler, Columbia College.
Prof. Wm. H. Carpenter, Columbia College.
Dr. J. Caumeigt, 228 West 43d Street, New York City.
Prof. Richard Gottheil, Columbia College.
Prof. A. V. Williams Jackson, Columbia College.
Prof. H. T. Peck, Columbia College.
Prof. E. D. Perry, Columbia College.
Prof. Thomas R. Price, Columbia College.
Prof. Henry A. Todd, Columbia College.
Mr. Gilbert van Ingen, Columbia College.
Prof. J. R. Wheeler, Columbia College.

Prof. Jacoby proposed the following new members:

Dr. W. S. Dennett, 8 East 49th St., New York City.
Dr. T. A. Humasson, 42 West 76th St., New York City.

The Section of Astronomy and Physics then organized. After reading the minutes, the Secretary announced that Prof. Mayer was absent on account of sickness and that consequently the paper by him would be postponed until the next meeting of the section.

Prof. Rees then called the attention of the section to the bill of Representative Hurley for the introduction and adoption of the metric system in the departments of the government and the country at large, and urged that some action be taken by the society looking to the endorsement of such a bill. It was decided to leave the discussion of this bill to a meeting of the Academy later in the evening.

Prof. Harold Jacoby then read a paper "On the Reduction of Astronomical Photographs taken near the Pole of the Heavens," and explained that the method consisted in taking a photograph of the pole of the heavens with a telescope stationary with reference to the earth. Under these circumstances each

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circum-polar star traces the arc of a circle on the plate exactly, and from a micrometric study of these curves it is possible to locate the pole exactly and also to determine the right ascension and declination of these stars. The method, if carried out through a number of years, would result in valuable additions to our knowledge of the variation of latitude, precession of the equinoxes, nutation and aberration constants.

The meeting of the Section then adjourned.

On the adjournment of the Section of Astromony and Physics the business meeting was resumed, President J. K. Rees in the chair.

After considerable discussion regarding the adoption of the metric system, which resulted from the paper previously presented by Prof. J. K. Rees, the following resolution was adopted, with the understanding that it should be brought by the Secretary before the Sections of Biology and Geology and then go to the Council, so that it might be acted upon at the annual meeting to be held on February 24th :

"*Resolved*, That the New York Academy of Sciences approves of the adoption of the metric system of weights and measures at the earliest practicable moment and that the Council of the Academy be requested to consider the matter with a view to bringing it before the Chairman of the Committee on Weights and Measures in Congress."

The Academy then adjourned.

J. F. KEMP,
Secretary.

STATED MEETING.

February 7th, 1896.

PROF. J. G. CURTIS in the Chair.

A communication from the Council was received, asking that the section take action on Representative Hurley's bill "To fix the standard of weights and measures by the adoption of the metric system of weights and measures."

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On motion of Dr. Dean the section approved the bill and the Secretary was directed to express the entire commendation of it to the Council.

Dr. Arnold Graf read a paper on "The Structure of the Nephridial in Clepsine." He finds in the cells of the intra-cellular duct fine cytoplasmic anastamosing threads which form a contractile mechanism. These are stimulated by granules which are most numerous near the lumen of the cell, and thus a peristalsis is set up which moves the urine out of the duct. In the upper part of the intra-cellular duct, the two or three cells next to the vesicle or funnel have no distinct lumen, but are vacuolated; the vacuoles of the first cell being small, those of the second larger, and so on till the vacuoles become permanent as a lumen. He explains the action of the first cell as being similar to the ingestion of particles by the infusorians. The matter taken up thus from the funnel by the first cell is carried by the rest, and so on till the cells having a lumen are reached. The presence of the excretum causes the granules to stimulate the muscular fibres of the cells; peristalsis results and the substance is carried outward. The character of this contractile reticulum offers an explanation of the structure of a cilium as being the continuation of a contractile reticular thread.

N. R. Harrington, in "Observations on the lime gland of the Earthworm," described the minute structure of these glands in *Lumbricus terrestris*, and showed that the lime is taken up from the blood by wandering connective tissue cells which form club-shaped projections on the lamellæ of the gland, and which pass off when filled with lime. The new cell comes up from the base of the older cell and repeats the process. This explanation is in harmony with the fact that in all other invertebrates lime is laid down by connective tissue cells. Histological structure and the developmental history confirm it.

Dr. Bashford Dean offered some observations on "Instinct in some of the lower Vertebrates." The young of *Amia calva*, the dogfish of the Western States, attach themselves, when newly hatched to the water plants at the bottom of the nest

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which the male *Amia* has built. They remain thus attached until the yolk sac is absorbed. As soon as they are fitted to get food they flock together in a dense cluster following the male. When hatched in an aquarium they go through the same processes. The young fry take food particles only when the particles are in motion, never when they are still. The larvæ of *Necturus* also take food particles that are in motion.

C. L. BRISTOL.
Secretary.

STATED MEETING.

February 17th, 1896.

The Academy met with Vice-President STEVENSON in the chair. About fifty persons were present.

The minutes of the last meeting were read and approved.

The section of Geology and Minerology then organized.

The Secretary presented the resolutions regarding the bill for the introduction of the Metric System of weights and measures as adopted by the section of Astronomy and Physics on February 3rd. It was approved by the section of Geology and referred to the Council.

The regular program was then taken up.

The first paper was presented by Mr. L. McI. Luquer, entitled "Notes on recent Accessions of Interesting Minerals," with exhibitions of specimens. Mr. Luquer described in detail the minerals that he had recently discovered at the feldspar quarries in the northeastern part of Westchester County. They included uraninite, autunite, uranophane, washing tonite and the common minerals of pegmatite veins. He showed that the veins occurred in close association with an area of augen-gneiss, regarded as intrusive and now being studied by himself and Mr. Heinrich Ries.

The second paper of the evening was by J. F. Kemp, entitled the "Cripple Creek Gold Mining District of Colorado." The

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paper was illustrated by about thirty lantern views, most of which were taken by the speaker during the last summer, and by an extensive series of specimens of rocks and ores.

After a brief historical review, the region was described in detail, without, however, introducing anything essential that is not already contained in the Cripple Creek Atlas Folio of the United States Geological Survey, which was prepared by Messrs. Cross and Penrose.

The Academy then adjourned.

J. F. KEMP,
Secretary.

ANNUAL BUSINESS MEETING.

February 24th, 1896.

The Academy met with President Rees in the Chair.

Fifteen persons were present.

The Minutes of the last meeting were read and approved.

The following names were presented for resident membership:
Mr. E. L. Godkin, No. 36 W. 10th St,
Dr. E. G. Love, No. 80 East 35th St,
Mr. Reginald Gordon, Columbia College,

and were referred to the Council. Israel C. Pierson, Ph. D., was nominated as Fellow.

The Academy then listened to the annual reports of the officers.

The first one was that of the Secretary as follows:

"The year past has been in many respects the most successful in the history of the Academy and we may feel encouraged that the Academy seems to be advancing more and more toward the place that it ought to occupy in the intellectual life of the city."

"During the year there have been held nine Meetings of the Council; nine Business Meetings; twenty stated Meetings of

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the Academy, of which one in the early fall failed of a quorum; six Public Lectures; one Public Reception.

The section of Astronomy and Physics has held eight meetings having generously surrendered one to a public lecture. The Sections of Biology and Geology have each held nine. The average attendance at the meetings of the first has been eighteen, a gain of four over last year. At the second the attendance has averaged forty, one meeting, February 10th, not having been reported, a gain of fifteen, which are especially due to two extra meetings in the nature of symposia. The Geological section has averaged twenty-five a gain of five.

"A total of seventy-eight papers, not counting public lectures, has been presented, divided as follows:

Anatomy.....	3,	Microscopy	1,
Astronomy 10,		Mineralogy	4,
Bacteriology....	1,	Paleontology 10,	
Botany	2,	Physics	7,
Chemistry.....	1,	Physiology	1,
Geology 20,		Psychology	1,
Mechanics, ...	3,	Travel	1,
Memorial.....	1,	Zoölogy 12,	
Total .....78.			

"Forty resident members have been elected, eight have resigned, and, so far as known, three have died, making a net total on the Secretary's list of 246, a gain of 30 over last year. Two corresponding members have been elected.

"A most important step has been the practical establishment of a new section in Philosophy and Philology, which will select an appropriate name and begin activities during the new year. Other departments, such as Psychology and Anthropology, are as yet not specially grouped in the sections.

"The public reception has become a regular feature of the year and has attracted very gratifying comment. The one held last March required a catalogue of 54 pages, which was distributed, bound up with Volume XIV. of the Transactions.

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"Sixteen signatures and forty-nine plates of Volume XIV. of the Transactions have been issued during the year, and the volume was distributed in September. It proved to be the largest volume of the Transactions yet issued. Parts 6–12 of Volume XIII. of the Annals have also been issued, bringing this volume to a close. Four signatures of Volume XV. of the Transactions have been printed and four or five more are now in press. Volume IX. of the Annals has has also been begun. An important departure has been made in the beginning of a quarto series of Memoirs, of which Part I. of Volume I. is now ready for distribution.

The second one was the Treasurer's report, and was referred to the Finance Committee for auditing. The report was as follows:

REPORT OF THE TREASURER OF THE NEW YORK ACADEMY OF SCIENCES FOR THE YEAR ENDING MARCH 24th, 1896.

RECEIPTS.

Balance on hand at last annual report.		
Current Account,	$843.93	
Savings Bank Account,	639.64	$1,483.57
Annual dues, 1892,	10.00	
" " 1893,	50.00	
" " 1894,	125.00	
" " 1895,	1,755.00	
" " 1896,	70.00	2,010.00
Initiation Fees,	110.00	
Patrons' Fees,	750.00	
Life Members' Fees,	1,000.00	
Interest on Investments and Deposits,	215.89	
Contributions towards Expenses of Second Annual Reception,	120.00	
Contributions to Huxley Memorial Fund (held for payment to General Committee),	105.00	2,300.89
		$5,794.46

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DISBURSEMENTS.

Expenses of Publishing Transactions,.....	$1,081.14	
" " Annals,.....	50.80	
" Recording Secretary,.....	80.24	
" Treasurer,.....	28.39	
" Librarian,.....	50.00	
" Lecture Committee, ...	85.00	
" Special Membership Committee,	51.50	
" Second Annual Reception,....	808.27	
Janitorial Services,.....	94.50	
Insurance Premiums,.....	20.00	
Dues to Scientific Alliance,.....	$138.00	$2,487.84
Balance on hand, Current Account, $312.59		
Balance of General Fund in Savings Bank, ... $2,994.03		$3,306.62

"During the year the Committee on the Audubon Monument have turned over to the Treasurer a balance of $1,797.25, remaining in their hands after payment for the monument, and this has been deposited in the Savings Bank under the title "Audubon Publication Fund."

The present assets of the Academy are as follows:

ASSETS.

Balance of Current Account, mentioned above,.....	$312.59
Balance of General Fund in Savings Bank, mentioned above, ...	2,994.03
Annual dues in arrears, for 1894, $80.00	
" " " " 1895, $170.00	250.00
General Publication Fund, amount at last report,.....$1,752.91	
Interest since credited,..... 70.78	1,823.69
Audubon Publication Fund,.....	1,797,25
$4,100 U. S. Four Per Cent. Bonds, due 1907 at 110,	4,510.00
Total, ...	$11,687.56

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"No unpaid bills remain in the hands of the Treasurer, and he has no official information of any outstanding liabilities, except the $105.00 collected and held for the Huxley Memorial Fund, included in the balance of Current Account mentioned above. Respectfully submitted,

(Signed) C. F. Cox,
Treasurer.

The Librarian's report was next submitted, as follows:

"All publications received have been stamped with the Academy stamp and turned over to the Librarian of Columbia College for shelving. Everything is properly distributed at date.

"The following new exchanges have been added to the mail ing list:

1. Université Royale d'Upsala, Sweden.
2. Kön. Biologische Anstalt, Helgoland.
3. Universität Jurivensis, Dorpat, Russia.
4. Astronomical and Physical Society of Toronto.
5. Rochester Academy of Sciences.
6. Missouri Geological Survey.
7. Chicago Academy of Sciences.
8. Oberlin College Library.
9. University of Indiana.
10. Free Library of the Public Schools, Huntington, Ind.

"Forty-six requests for back numbers of the Academy's publications have been received and attended to. Of these twenty-five were foreign and twenty-one domestic. The foreign packages were sent through the bureau of International Exchanges, Smithsonian Institution. The domestic were sent either by mail or express, according to size. Express packages were sent C. O. D. Sixty-six letters were written in answer to inquiries regarding back numbers, new exchanges, subscriptions, etc.

"Sixty-nine return acknowledgments were sent for packages of publications received.

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"Nine dollars and seventy-five cents ($9.75) were received in subscriptions for back numbers from non-members. Requests for back numbers from members or from institutions on the exchange list were honored without charge.

"The Librarian's expenses have been:

Postage,	$8.98
Express,	3.80
Messenger,	.10
Total,	$12.88

(Signed) ARTHUR HOLLICK,
Librarian."

These were followed by the report of the Corresponding Secretary, which was verbally made.

Members of the Academy then asked about the progress of the new quarto series of Memoirs and about the recent issue of the Annals.

It was moved and carried that as a token of appreciation on the part of the Academy that a vote of thanks be passed to Mr. Rutherfurd Stuyvesant for his generous contributions to the publication funds of the Academy, and to Captain T. L. Casey, U. S. A., for his contributions toward the issue of the Annals.

Reports from the Secretaries of the several sections were then called for and were given by Prof. Wm. Hallock for the section of Astronomy and Physics; Prof. N. L. Britton for the section of Biology, and Prof. J. F. Kemp for the section of Geology and Mineralogy.

The Academy then proceeded to the election of officers for the ensuing year. The following received the unanimous vote of the Academy. Messrs. Britton and Wade were appointed tellers.

For President, J. J. Stevenson.
For First Vice-President, H. F. Osborn.
For Second Vice-President, R. S. Woodward.
For Corresponding Secretary, D. S. Martin.

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For Recording Secretary, J. F. Kemp.

For Treasurer, C. F. Cox.

For Librarian, Arthur Hollick.

For Councilors, J. A. Allen, N. L. Britton, R. E. Dodge, William Hallock, J. K. Rees, Wm. Stratford.

For Curators, H. G. Dyar, G. F. Kunz, L. H. Laudy, Heinrich Ries, W. D. Schoonmaker.

For Finance Committee, Henry Dudley, J. H. Hinton, Cornelius Van Brunt.

Newly elected President Stevenson then took the Chair.

It was moved and carried that the evening of Monday, March 30th, be assigned to retiring President Rees for a Presidential address.

The Academy then adjourned.

J. F. KEMP,
Secretary.

REGULAR BUSINESS MEETING.

March 2d, 1896.

The Academy met with President STEVENSON in the Chair. Twenty-six persons were present.

The minutes of the last meeting were read and approved.

The Secretary presented the following names from the Council for resident membership, and on motion they were all elected: W. S. Dennett, M. D., E. L. Godkin, Reginald Gordon, T. A. Humasson and E. G. Love. And for Fellow, Israel C. Pierson.

The following new nominations were referred to the Council in due course:

Professor Daniel W. Hering, University Heights, New York City, Professor of Physics in the University of the City of New York; nominated by J. J. Stevensen. Henry Piffard, M. D., No. 10 West 35th street; nominated by C. F. Cox. Th. Weston, No. 14 West 48th street; nominated by Harold Jacoby.

The Section of Astronomy and Physics then organized.

The minutes of the last meeting were ready and approved.

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The first business of the evening was the election of officers for the ensuing year. Professor Rees nominated R. S. Woodward for Chairman and W. Hallock for Secretary. On motion the nominations were then closed, and the motion was put by Professor Rees to authorize Mr. Wade, as teller, to cast the ballot in favor of the gentlemen for the office named. The motion was carried and the teller reported the vote cast.

The first paper of the evening was upon the apparatus designed by Professor W. L. Robb for showing the way in which a cord vibrates. It consisted essentially of an electro-magnet running a vibrating arm to the end of which the string is attached.

The second paper was upon a new form of Polariscope, designed by Professor A. M. Mayer, consisting of a special arrangement of cross lenses resulting in unusually good illuminations and large field.

The next paper was upon the Heliostat designed by Professor Mayer. In this connection Professor Mayer called attention to the shortcomings of the various forms of heliostat, and especially those using only one mirror, pointing out, among other things, the useless width of mirrors on such heliostats and illustrating what ought to be the dimensions of such a mirror. He also called attention to the great advantage of using sunlight for all optical experiments over any form of electric light; for example, with a heliostat and condensing system he was able to project the interference bands of the Fresnel bi-prism upon a screen so that they are visible across a large room. Prof. Mayer's heliostat consists in a clockwork driving a shaft parallel to the earth's axis; upon the southern end of the shaft is attached the mirror that can either be adjusted to the shaft or set at any angle to the shaft. The second mirror is mounted upon the base with its central point in the prolongation of the shaft. To orient the heliostat it is only necessary to bring the side pieces in the north and south line and then set the mirror on the clock axis. This last is done by covering the elliptical mirror with a piece of paper having $\frac{1}{2}$-inch hole in the center and adjusting the tilting mirror until the small beam of

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light reflected from the mirror through the hole falls upon the center of the mirror attached to the base of the instrument; then starting the clock the instrument will keep the beam in a constant position. Prof. Hallock in discussing the paper called attention to the accuracy with which the heliostat operated and related his experience with a very large one-mirror heliostat in the Smithsonian Institution at Washington, which, however, was thoroughly unsatisfactory. Prof. Woodward and Prof. Jacoby also entered into the discussion of the relative merits of the various heliostats, especially the typical one-mirror and two-mirror types.

Prof. M. I. Pupin then brought before the Academy some recent observations he had made while experimenting with X-rays. In the first place he pointed out that many Crook's tubes after a certain amount of use had their vacuum improved, so that the induction spark passed outside the tube rather than through it. Prof. Pupin was at a loss to altogether satisfactorily explain the cause, but believed that it might possibly be due to the condensation of some of the gas remaining in the tube, and explained several experiments which he had made already confirming the observation that the vacuum was improved with use, and that in proportion as the vacuum improved the tubes were better for X-ray photography. Another of the phenomena observed by him was that in developing the photographic plates the development began at the glass side of the film and not at the outside of the film, leading to the inference that the rays penetrated the film and rendered the glass fluorescent, this fluorescent light then acting upon the film. Following the suggestion of this observation he painted the inside of a box with platinum-barium-cyanide and laid a photographic plate against it, making a photograph then through the sides of the box. The X-rays develop the fluorescence in the cyanide and then penetrate the plate. He obtained very good results with much shorter exposures than by the original method.

On motion the meeting then adjourned.

J. F. KEMP,
Secretary.

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STATED MEETING.

March 9th, 1896.

In the absence of regular business, the Section of Biology at once organized, PROF. CURTIS in the chair, Dr. DYAR, Secretary *pro tem.* In the absence of the Secretary, the reading of the minutes was omitted.

Mr. F. B. Sumner read the following paper:

THE VARIETAL TREE OF A PHILIPPINE PULMONATE.

BY FRANCIS B. SUMNER.

An expedition recently sent to the Philippine Islands, under the direction of the Minnesota Academy of Sciences, procured among other things of great value some most interesting sets of land shells. These, in addition to their value to the systematic conchologist, present some striking examples of the phenomena of variation.

The accompanying figure (see Plate VI., at end of volume) represents a varietal tree, constructed by the writer from shells of the pulmonate *Cochlostyla ovoidea*, obtained on Masbate Island. The genus *Cochlostyla* is a very large one, comprising, as stated by Cooke (Cambridge Natural History, Vol. I., "Mollusca") no less than 247 species. Many of the species are of extreme variability, serving as an excellent illustration of the law laid down by Darwin that the larger genera present as a rule the most variable species.

This species varies in shape, size and color. In length, adult specimens were found varying from 1.05 inches to 1.80 inches. Differences in shape I determined by comparing the ratio of length to breadth. In the stoutest specimens, length $= 1.76 \times$ breadth. In the slenderest, length $= 2.29 \times$ breadth.

But by far the most striking differences are those of color and ornamentation. These are fairly well, although by no means perfectly represented by the figure.*

On comparing any one of the color varieties of this species with any other, I found it possible to bridge over the gap by

*I wish to here express my indebtedness to Prof. Henry F. Nachtrieb, for the loan of the set, and to Dr. Edward Leaming, for his care in securing a satisfactory photograph.

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insensible gradations, and, placing the most extreme forms at the termini of the branches, such a tree as I have represented was the result. But, having once constructed such a tree, no other arrangement is possible. We cannot, for example, pass from 6 to 6″ except in the manner indicated, *i. e.*, by passing down one stem and up the other. Indeed, we can give to almost every shell which was obtained a place corresponding to one of the numbers of the figure. A very few slightly aberrant forms were found, to be sure, but I thought it best not to complicate the tree by introducing them. Three such are represented in the right-hand lower corner of the figure.

It will, doubtless, be asked why I have assumed 0 to be the typical form and placed it at the apex. This I did for two reasons: Firstly, this variety preponderates greatly in number. Out of 538 specimens which were obtained, 318 belonged to the three central numbers of the series (0, 1 and 1′) while the remaining 220 (with a very few exceptions) belonged to the other fourteen numbers. Secondly, the genus seems typically to possess three bands. Of the 22 species, or thereabouts, obtained by the expedition, thirteen exhibit bands either constantly or occasionally, and of these, nine either constantly or occasionally exhibit three bands. Moreover, we have reason to believe that the others have been modified through the fusion or loss of some or all of them.

Examining our tree, we find that the central member (0) presents upon each whorl three bands of approximately equal width and equal depth of color, all being of a dark black-walnut shade. Passing up the right hand branch of the series, we find that the upper band begins to narrow and to pale until it is completely lost. This happens also with the lowest band, only this one disappears a little later than the upper one. The central band persists to the last undiminished. On the left-hand branch, we observe a quite different transformation. The upper and lower bands begin to lose their sharp outlines, becoming blurred along their edges. This process of spreading continues until the color has diffused itself toward the central band, filling in the white interspaces. The effect is the same as if the pigment had been fresh paint and had been first laid on in streaks and then spread out with a brush. From about the position of 3′ two branches now lead off, presenting opposite tendencies. Both agree in continuing this diffusion of color and obliteration of the bands, but whereas on the left hand side, the color deepens and the entire mass is now nearly as dark as were the original markings; on the right hand the color pales and the result is a mustard tint. In the dark form, again, the central band persists

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although no longer distinct in outline; in the light form there is the merest trace of this.

These varieties are named by Sr. Quadras, a conchologist at Manila, as follows: 0, he agrees with me in regarding as the type. "Those with broad bands" (presumably the lower members of the left-hand stem), var. *euryzona*. "Those entirely white" (he perhaps refers to the right-hand stem, although none are *entirely* white), var. *nana*. "Those with yellow epidermis, with or without small bands" (probably 5′ and 6′) var. *opaca*.

It is of especial interest to observe the order in which these bands disappear. Calling the bands in order from top to bottom, A, B and C, we have seen that A is the first to disappear, while C soon follows, and that B persists to the last unaltered. I did not find a single specimen which contradicted this rule. If two bands were present, they were invariably B and C, if only one, B. Now, it is interesting in this connection to compare *Cochlostyla ovoidea* with other members of the same genus. I have only examined about twenty-two species. The following are the results:

In several species there was a single band occurring constantly or occasionally. This was invariably B.

In one species there was either an entire absence of bands or B alone or B and C.

In a number of other species, the number of bands varied from one to three. In these cases the rule was adhered to with occasional exceptions. Finally, there were a few with all three invariably and a number (about nine) entirely destitute of markings.

In the related genus Helix, which possesses typically five bands, the central one is the last to disappear.

Another phenomenon of interest, illustrated by this set is that of correlative variation. In this species there seems to be some sort of a correlation between size and color. I measured the length of every shell obtained (538 in all), and found as a result that the average length of all those belonging to the central place (0) and to the whole left hand branch was 1.3 inches. The average length of the specimens belonging to the three terminal places of the right hand stem was 1.47. Those intermediate between 0 and the latter were intermediate in length. The greater size of the white shells 3, 4, 5 and 6, is quite noticeable in the figure.

Such are the observable facts in regard to these shells. Their chief interest evidently lies in their relation to the general problems of variation. With the few data which we possess, definite conclusions are premature, but it may not be unprofitable

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to seek some sort of explanation of the facts we are dealing with.

If we found these successive modifications of the type form in successive geological strata, we should of course conclude that these varieties were on the way to becoming species, in other words that we had to do with a case of evolution. But here we are dealing with contemporaneous forms inhabitating apparently the same habitat. Mr. D. C. Worcester, who collected these shells, informs me that he was unable to discover any evidence of local distribution. He states further that, with regard to another *Cochlostyla* nearly as variable as this, he can state positively that the various extremes are often found feeding upon the same clump of bamboo. Quadras writes that those found in the valleys are generally smaller than those found near the seashore, but mentions no local distribution in reference to color. Moreover we have no evidence to show that these various extremes do not freely interbreed or that the most unlike of them may not hatch from the eggs of the same parents. Indeed, if there is no local distribution, it is inconceivable that the different varieties should breed true.

Consider also that no theory of evolution yet offered is competent to explain how these varieties can become fixed species. Any theory which appeals to the direct action of environment has no application, for here the environment is the same for all. Against the operation of Natural Selection we can offer objections equally valid. We should be forced under this hypothesis to assign some utility to these markings, the most plausible view being that they are of protective value. But Mr. Worcester writes, in reply to a question of mine on this point: "After thinking the matter over a good deal, I incline to the opinion that we have to do here with variations neither especially useful nor especially harmful." And, indeed, it is in the highest degree improbable that animals with like habits could be protected equally well by such a number of colors. Again, if Natural Selection were here in operation, we should expect to find the terminal forms of the tree, *i. e.*, the most improved, to preponderate greatly in number, for Natural Selection can only operate by the extinction of the unimproved. But a count of the specimens finds the reverse to be the case:

0, 1, 1′	318
2, 3	41
4, 5, 6	18
2′, 3′, 4′	66
5′, 6′, 7′	16
4″, 5″, 6″	67
Unclassed	9

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So I think we can find no reason for believing that we have to do with a case of progressive modification, however much our varietal tree may suggest a genetic tree. It seems more probable to suppose that even the most extreme of these forms may hatch from the same batch of eggs. And here we have a beautiful example of the definite tendency of variation. Variation must take place along certain lines predetermined by the nature of the organism.

It is to be regretted that we have so few biological data in regard to this and allied species. Future explorations will perhaps yield these.

ZOÖLOGICAL LABORATORY,
COLUMBIA UNIVERSITY, March, 1896.

Prof. Osborn, in discussion, coincided with the view that the variation could not be explained by natural selection. Dr. Dyar, however, thought the explanation by natural selection not necessarily excluded, since the variations seemed analogous to the dimorphism in sphinx larvæ, which has been shown by Poulton to be probably due to this factor.

The other paper was by Dr. Arnold Graf, on "The Problem of the Transmission of Acquired Characters."

Dr. Graf discussed the views of the modern schools of evolutionists and adopted the view that the transmission of acquired characters must be admitted to occur. He cited several examples which seemed to support this view, and especially discussed the sucker in leeches as an adaptation to parasitism and the evolution of the chambered shell in a series of fossil Cephalopods.

Professor Osborn remarked in criticism of Dr. Graf's paper that this statement does not appear to recognize the distinction between *ontogenic* and *phylogenic* variation, or that the adult form of any organism is an exponent of the stirp, or constitution + the environment. If the environment is normal the adult will be normal, but if the environment (which includes all the atmospheric, chemical, nutritive, motor and psychical circumstances under which the animal is reared) were to change, the adult would change correspondingly; and these changes would be so profound that in many cases it would appear as if

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the constitution, or stirp, had also changed. Illustrations might be given of changes of the most profound character induced by changes in either of the above factors of environment, and in the case of the motor factor or animal motion the habits of the animal would, in the course of a life time, profoundly modify its structure. For example, if the human infant were brought up in the branches of a tree as an arboreal type instead of as a terrestrial, bi-pedal type, there is little doubt that some of the well known early adaptations to arboreal habit (such as the turning in of the soles of the feet, and the grasping of the hands) might be retained and cultivated; thus a profoundly different type of man would be produced. Similar changes in the action of environment are constantly in progress in nature, since there is no doubt that the changes of environment and the habits which it so brings about far outstrip all changes in constitution. This fact, which has not been sufficiently emphasized before, offers an explanation of the evidence advanced by Cope and other writers that change in the forms of the skeletons of the vertebrates first appears in ontogeny and subsequently in phylogeny. During the enormously long period of time in which habits induce ontogenic variations it is possible for natural selection to work very slowly and gradually upon predispositions to useful correlated variations, and thus what are primarily *ontogenic variations* become slowly apparent as *phylogenic variations* or congenital characters of the race. Man, for instance, has been upon the earth perhaps seventy thousand years; natural selection has been slowly operating upon certain of these predispositions, but has not yet eliminated those traces of the human arboreal habits, nor completely adapted the human frame to the upright position. This is as much an expression of habit and ontogenic variation as it is a constitutional character. Very similar views were expressed to the speaker in a conversation recently held with Professor Lloyd Morgan, and it appears as if a similar conclusion had been arrived at independently. Professor Morgan believed that this explanation could be applied to all cases of adaptive modification, but it is evident that this cannot be so, because the teeth also undergo the same progressively adaptive

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evolution along determinate lines as the skeleton, and yet it is well known that they do not improve by use, but rather deteriorate. Thus the explanation is not one which satisfies all cases, but it does seem to meet, and to a certain extent undermine, the special cases of evidence of the inheritance of acquired characters, collected by Professor Cope in his well-known papers upon this subject. HARRISON G. DYAR, *Secretary pro. tem.*,
(per C. L. B.)

STATED MEETING.

March 14th, 1896.

The Academy met with President STEVENSON in the chair; twelve persons present.

The minutes of the previous meeting were read and approved.

The following nominations for resident membership were received and referred to the Council: Mr. Louis C. Whiton. 114 West 76th St.; Mr. Wm. F. Havemeyer, 29 West 19th St.; Prof. J. Dyneley Prince, 19 West 34th St.; Prof. Charles B. Bliss, University Heights, New York; Prof. Lawrence A. McLouth, University Heights, New York; Dr. Emil Leytter, 305 West 127th St.; Prof. F. H. Giddings, Columbia University.

The Section of Geology and Mineralogy then organized.

The first paper of the evening was by Mr. Heinrich Ries, on "A Visit to the Bauxite Mines of Georgia and Alabama." Mr. Ries described the geological relations of the bauxite deposits of the region, basing his remarks on notes taken last October. The paper was illustrated by numerous lantern views and specimens and was discussed by Messrs. Dodge and Kemp.

The second paper of the evening was by Prof. R. E. Dodge, on the "Cretaceous and Tertiary Peneplains of Eastern Tennessee," on the basis of observations accumulated during two summers' field work in the region under Mr. C. W. Hayes, of the U. S. Geological Survey. The speaker described the geo-

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graphic development since the Cretaceous period of the country lying west from Chattanooga across the Sequatchie valley to the Mississippi river. The Cretaceous and Tertiary peneplains were illustrated by means of maps and sections, and the present development of the drainage system was traced out. President Stevenson, in discussing the subject, described his own observations in West Virginia and western Pennsylvania.

The Section then proceeded to the election of officers for the ensuing year: Professor J. J. Stevenson was chosen Chairman and Professor J. F. Kemp, Secretary.

The Academy then adjourned.

J. F. KEMP, *Secretary.*

ON THE OCCURRENCE OF CIRRIPEDES IN THE CAMBRIAN ROCKS OF NORTH AMERICA.

BY G. F. MATTHEW.

In a revision of material collected from the Cambrian rocks of Canada and Newfoundland, the author has investigated some peculiar calcareous plates which occur at several horizons; as a result he has come to the conclusion that these are the scattered tegumentary plates of animals related to the barnacles.

These plates are of various forms, but the majority agree in having a carina, usually nearer one side than the other. From the fact that the plates are depressed on one side of the carina and elevated on the other, it may be inferred that they are parts of imbricated series. Occasionally plates are found which are convex on both sides of the carina; such plates are more symmetrical than the others.

The above plates differ from Plumulites of Barrande in being comparatively *smooth*, the only sculpturing of the surface being delicate growth lines near the lower margin.

Beside the above plates there are other plates marked by sharply raised, closely set ridges, parallel to the lower margin. Some of these agree perfectly with Barrande's Plumulites, others are more arcuate, others still have more distant growth ridges, etc.

Such is the variety of form in the smooth plates that it is highly probable that more than one species (perhaps more than one genus) is represented. But as the plates found were de-

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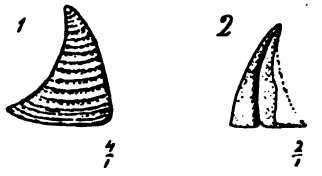
tached from each other, and scattered over layers of the shale, it is quite impossible to determine this point. For the smooth plates I would suggest the name Cirripodites. One of these plates and a Plumulites are figured below.



1. *Plumulites Manuelensis*, Mag 4/1. From the subzone of Paradoxides Davidis, Manuel Brook, Newfoundland.
2. *Cirripodites Acadicus*, triangular form, Mag. 4/1. From the subzone of P. Eteminicus, St. John, N. B., Canada.

All the plates so far found belong to the Paradoxide Zone. In America this zone contains four subzones, viz.:

1. Subzone of P. lamellatus (cf. Œlandicus).
2. " " P. Eteminicus (cf. rugulosus).
3. " " P. Abenacus (cf. Tessini).
4. " " P. Davidis (the highest subzone).

In Sweden there are two higher subzones in the Paradoxides beds.

Plates of Cirripedes have been found in the second and fourth subzones; and certain fossils which probably are of this type of crustacean, from the third subzone. The fossils from the several subzones differ so far as to show that they are probably of different genera.

A fuller account of these interesting fossils will be given in an article which the author has in preparation, on the Fauna of the Paradoxides Zone in America.

In reference to the use of the generic names given above, a few words may be said. Apparently there has been a diversity of practice in the use of terms to designate these fossils.

Dr. Henry Woodward* argues for the use of Turrilepas as against Plumulites, on the ground of priority of publication. Barrande first found Plumulites in the Ordovician rocks (Etage D.) of Bohemia, whereas Dr. Woodward's Turrilepas came from the Silurian, and it seems altogether probable that they are different genera.

Dr. H. M. Ami has found plates in the Utica beds near Ottawa, which very closely resemble some of Barrande's figures;

* Geolog. Mag. London, New Ser. Dec. iii., vol. vi., p. 272.

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and in the collections of Columbia College, New York, there are plates from the same horizon at Plattsburg, N. Y., having the form and markings of Plumulites. In view of the very diverse types of Cirripedes figured by Dr. J. M. Clarke,* in which the individual plates show no greater diversity of form than those called Plumulites by Barrande, it seems to me quite within the range of convenient use to utilize this term of Barrande for detached, corrugated plates of Cirripedes of the Ordovician and earlier time. Perhaps a fortunate happening of discovery shall before long enable us to relegate certain of them to a more definite genus.

St. John, N. B., Canada, March, 1896.

Regular Public Lecture.

March 23d, 1896.

The Academy met in the Law School of Columbia University to listen to the regular public lecture for the month. Professor Stevenson presided, and about 350 people were present.

Before the lecture began the following two names were presented for resident membership and referred to the Council in the regular course: Mr. A. S. Frissell, Mr. Thaddeus R. White.

President Stevenson then introduced Professor M. I. Pupin, who delivered the lecture on "Roentgen's Discovery" and illustrated his remarks by experiments and the lantern. At the close of the lecture a vote of thanks was given the lecturer.

The Academy then adjourned.

J. F. Kemp, *Secretary.*

Stated Meeting.

March 30th, 1896.

The Academy met and listened to an address by the retiring President, Professor J. K. Rees, upon the subject "Some Problems About to Confront Astronomers of the Twentieth Cen-

* Am. Geologist, vol. xvii., No. 3, p. 143.

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tury." The address appeared in full in SCIENCE of May 15, 1896. About twenty-five persons were present. At the conclusion of the lecture the Academy adjourned, after passing a vote of thanks to the lecturer.

REGULAR BUSINESS MEETING.

April 6th, 1896.

The Academy met with President STEVENSON in the chair. There were about forty persons present.

The Secretary presented the following nominations from the Council, all of whom were elected:

Henry M. Alexander, Frederick C. Beach, Charles B. Bliss, James M. Donald, James Douglass, Scott Foster, A. S. Frissell, F. H. Giddings, Frank J. Gould, Miss Helen Gould, Thomas E. Greacen, Wm. F. Havemeyer, Marcellus Hartley, Daniel W. Hering, Edmund J. Levine, Emil Leytter, Lawrence A. McLouth, Alfred Pell, Henry G. Piffard, J. Dyneley Prince, Wm. T. Sabine, Louis Mann Silver, Francis H. Stoddard, James Stokes, Th. Weston, Thaddeus R. White, Louis C. Whiton.

The Section of Astronomy and Physics then organized and listened to the following program:

P. H. Dudley, "The Law of Deflection Sets under Drop Tests in different Sections of Steel Rails of uniform physical Properties follows the comparative Moments of Inertia of the respective Sections."

Harold Jacoby, "On the Permanence of the Rutherfurd Photographs."

Remarks by J. K. Rees, on: (1) "The Harvard College Observatory photographs of star clusters, planets, variable stars and stellar spectra." (2) "Prof. J. E. Keeler's photographs of planetary spectra." Illustrated by photographs and lantern slides.

M. I. Pupin, "Communication of some new Results of Experi-

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ments with the Röntgen Rays." Experimental demonstration followed in the Electrical Laboratory of Columbia University.

J. F. KEMP,
Secretary.

STATED MEETING.

April 13th, 1896.

The Academy met with President STEVENSON in the chair. Twenty-five persons present.

The minutes of the last meeting were read and approved.

The Section of Biology then organized and listened to the following program:

Tarleton H. Bean, "The Habits of the Young of the Pacific Salmon."

Oliver S. Strong, "A Case of Degeneration of the Optic Nerve in the Brain of the Skate, *Raja erinacea.*"

H. F. Osborn, "A Mode of Evolution requiring neither Natural Selection nor the Inheritance of Acquired Characters. An abstract appears on a subsequent page.

J. F. KEMP,
Secretary.

RECENT NOTES ON BACTERIA.

BY HARRISON G. DYAR, PH. D., ASSISTANT IN BACTERIOLOGY. DEPARTMENT OF PATHOLOGY, COLUMBIA UNIVERSITY, N. Y.

"I would recommend * * * that all who describe new species should be urged to afford a second description twelve months later * * * stating accurately how far the forms have become modified by continued growth on ordinary standard media."

This suggestion of Dr. J. G. Adami (Jour. American Public Health Association, XX., 418, Oct., 1895), has appeared to me a valuable one and I have accordingly put it into practice by re-planting the "new species" of Bacteria described by me (Ann. N. Y. Academy of Science, VIII., 322–380). The following is the result of this planting during February and March, 1896.

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The period which has elapsed since the first planting, which is the one recorded in my former paper, varies from one to two years.

1. MERISMOPEDIA FLAVA VARIANS.

The morphology represents now a well packeted Sarcina instead of a Merismopedia and the gelatin is slowly liquefied, in one culture in 33 days, and in another made at the same time only in 50 days. The characters on the other media have not changed, except that nitrate is rather less quickly reduced, the full reduction not being obtained till 28 days.

6. MICROCOCCUS SIMILIS.

The cultures are dead.

3. MICROCOCCUS CEREUS AUREUS.

The characters have not changed.

12. MICROCOCCUS CREMOIDES AUREUS.

The cultures faded to the color of *M. cremoides*, but retained their growth characters. Fresh cultures with the normal orange color were readily obtained from the air.

14. MICROCOCCUS CREMOIDES ALBUS.

The cultures were lost, but those of *M. cremoides* had faded to pure white, retaining their other characters.

21. MERISMOPEDIA FRAGILIS.

The cultures are dead.

23. MERISMOPEDIA MOLLIS.

Characters scarcely changed. The growth is less abundant than a year ago, the orange color most distinct in the condensation water in the bottom of the tube. Lactose litmus agar is made blue.

25. MICROCOCCUS DISSIMILIS.

Characters unchanged except that the cells were seen to be associated in pairs and fours as well as singly, thus representing a Merismopedia.

33. MERISMOPEDIA MESENTERICUS CORRUGATUS.

The growth characters are exactly the same, and in addition a slight pink tint was seen in the liquefied gelatin. Milk is affected exactly as by *B. lactis erythrogenes*, being apparently coagulated, but on boiling the coagulum disappears. A careful examination of the cells shows them to be slightly elongated, yet associated in pairs and fours. A second culture, also

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marked "*Staphylococcus pyogenes citreus*," was found in the collection. It was the same in all respects, but the growth was soft and not wrinkly. Cells in pairs and fours, but often slightly elongated.

My reason for rejecting the determination of these cultures and applying a new name was that *Staphylococcus pyogenes citreus* is described as the same on all media as *Staph. pyog. aureus*, which is not the case here. However, if "all media" refers only to gelatin, agar and potato, my construction of the description may have been too rigid and the cultures may be correctly named. I do not otherwise know *S. pyogenes citreus*.

36. BACILLUS SARRACENICOLUS.

37. BACILLUS VACUOLATUS.

The cultures are dead.

39. BACILLUS SUBOCHRACEUS.

The characters are unchanged except that milk is more quickly coagulated (9 days), but only on boiling even in 26 days. Nitrate is very decidedly more strongly reduced yet not completely. The species is a facultative anaerob.

40. BACILLUS DOMESTICUS.

This species now liquefies gelatin. The liquefaction begins after about 34 days and proceeds slowly. In 50 days about one-fourth of the medium in the tube was liquefied.

There is also a pink tint in the liquefied part. Nitrate is less strongly reduced, not completely in 30 days. Milk is not coagulated at first, but in 31 days a coagulum was obtained on boiling. Lactose-litmus agar is reddened as before and the yellow color is retained, otherwise the species is scarcely recognizable. The cells are shorter than before, sometimes scarcely distinguishable from Micrococci. The species is aerobic.

44. BACILLUS JAVANIENSIS.

The nitrate was not reduced at all, otherwise the characters remain the same.

54. BACILLUS FUSCUS PALLIDIOR.

55. BACILLUS FERRUGINEUS.

56. BACILLUS SALMONEUS.

57. BACILLUS FINITIMUS RUBER.

The characters are unchanged.

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59. BACILLUS BRUNNEOFLAVUS.

The nitrate is decidedly more strongly reduced, yet not completely so. Otherwise as before.

60. BACILLUS PROPINQUUS.*

The characters are the same in general; but in the Fall all the gelatin tubes were found to be liquefied. On replanting no liquefaction was obtained in 74 days when a spell of hot weather (26° C. in the laboratory) occurred. After it had passed, old gelatin tubes remained fluid, while young ones (21 days) hardened again. The cells are now very short, almost like cocci.

62. BACILLUS DECOLORANS MAJOR.

Rosalic acid decolorized in 13 days, but nitrate not reduced. Otherwise as before.

65. BACILLUS TYPHI ABDOMINALIS.

The culture marked (2) was lost. The one marked (3) remained constant in all its characters. The culture is not the true *B. typhi abdominalis*, as it is distinctly aerobic and grows dark brown on potato. (Compare the pseudo-typhoid germs found by Dr. Th. Smith, Am. Journ. Med. Sciences, Sept., 1895, culture no. 28.)

68. BACILLUS INUTILIS.

Growth characters unchanged, but the cells are decidedly shorter, not distinguishable from cocci.

70. BACILLUS ALPHA.

71. BACILLUS BETA.

The cultures are dead.

76. BACILLUS GAMMA.

Nearly dead. A very poor slight growth persists, but is incapable of liquefying gelatin or repeating its other former characters.

78. BACILLUS DELTA.

The cultures are dead.

81. BACILLUS HUDSONII.

82. BACILLUS OXYLATICUS.

The characters are unchanged.

83. BACILLUS EPSILON.

*I have inadvertently applied the name *flavocoriaceus* to two species (43 and 60), differing only in the power of reducing nitrate, No. 60 may be designated as above.

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84. BACILLUS ZETA.

The cultures are dead.

102. BACILLUS M. FUSCUS CONSISTENS.

Nitrate was not reduced and the growth was not distinctly wrinkly. Otherwise the same.

110. BACILLUS FUSCUS LIQUEFACIENS.

Unchanged, except that the nitrate was not reduced.

112. BACILLUS KAPPA.

Rosalic acid decolorized as before. Milk peculiarly affected. It is not coagulated at first, but in 23 days the whole mass resembles a starch paste, on boiling becoming jelly-like with thick flocculi. Otherwise the same.

114. BACILLUS PLYMOUTHENSIS.

Exactly as in *B. rosaceus metalloides*. The growth is no longer viscous. Lactose litmus agar is not reddened by this species, which would seem to show that the reddening of the lactose-litmus gelatin was due to some product of the liquefied gelatin.

116. BACILLUS KRALII.

Apparently overgrown by a contamination.

117. BACILLUS LARVACIDA.

Unchanged.

120. BACILLUS PYOGENES FŒTIDUS LIQUEFACIENS (Lanz).*

Nitrate completely reduced in 28 days. Rosalic acid is deepened in color. Otherwise as before.

121. BACILLUS PRUDDENI.

Unchanged.

123. BACILLUS BOOKERI.

The lactose litmus agar, while reddened at first, ultimately became blue. The nitrate was strongly reduced as before, and the other characters were the same.

126. BACILLUS SORDIDUS.

Unchanged.

I draw the following conclusions from the results of these replantings.

(1) Species under long cultivation, such as I have received from collections, tend to be constant in their characters.

* Centralblatt f. Bacteriol., XIV., 277.

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(2) Some species lose in vigor on repeated cultivation and become incapable of exhibiting certain of their characters, or finally die.

(3) Some species gain in vigor on repeated cultivation, exhibiting certain characters more strongly or even acquiring new ones.

The changes observed for the several species are arranged below in tabular form.

Cultures which died.	Cultures becoming less vigorous, their characters becoming less positive.	Cultures constant.	Cultures becoming more vigorous, with more positive or new characters.
			1. Gelatin is now liquefied.
6 70 84	12. The color becomes paler.	8 56 102 121	25. The cells are more firmly united.
21 71	13. The color becomes white.	33 57 110 126	39. Milk more quickly coagulated.
36 78	25. The growth is less abundant.	54 65 114	40. The gelatin is now liquefied, etc.
37 88	44. Nitrate no longer reduced.	55 81 117	59. Nitrate more strongly reduced.
	68. The cells are shorter.		62. Rosalic acid more quickly decolored.
	70. Gelatin no longer liquefied.		112. Milk more distinctly coagulated.
			120. Nitrate is now reduced.
			123. Lactose litmus agar finally made blue, instead of being simply reddened.

Stated Meeting.

April 20th, 1896.

The Academy met with President Stevenson in the chair. Eighteen persons were present.

The minutes of the last meeting were read and approved.

The Secretary presented the nomination of Mr. E. E. Olcott for resident membership, and it was referred in due course to the Council.

The Section of Geology and Mineralogy then organized and listened to the first paper of the evening, by Mr. John D. Irving, on "The Stratigraphy of the Browns Park Beds, Utah." The paper will appear subsequently in the Transactions.

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The second paper of the evening, was by C. H. Smyth, Jr., on "The Origin of the Talc Deposits near Gouverneur, N. Y." The paper was read by Mr. L. M. Luquer in the absence of the writer, and it will appear in full in the *School of Mines Quarterly*, for July, 1896.

The third paper of the evening, was by H. P. Cushing, entitled: "On the Existence of Pre-Cambrian and Post-Ordovician Trap Dykes in the Adirondacks." The paper will appear subsequently in the TRANSACTIONS.

The Academy then adjourned.

J. F. KEMP,
Secretary.

STATED MEETING.

April 27th, 1896.

The Academy met with President STEVENSON in the chair. About thirty persons present. No minutes were read, as it was the first meeting of a new section.

Mr. Rush Taggart was nominated as resident member, and the nomination was referred to the Council.

The Academy then proceeded to organize a section in Anthropology, Psychology and Philology. Prof. N. M. Butler was nominated for temporary chairman.

Prof. F. H. Giddings was nominated and elected as permanent chairman, and Dr. Livingston Farrand was chosen secretary for the subsection of Anthropology and Psychology, and Prof. A. V. Williams Jackson, secretary of the subsection of Philology. It was resolved to have a meeting of the subsection of Anthropology and Psychology one month and of the subsection of Philology the next. The officers were elected for a term that will end at the annual meeting of the Academy.

Prof. Giddings took the chair and the reading of the papers followed.

The first paper was by F. H. Giddings, entitled "A Plan for

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the Systematic Study of Tribally Organized Societies." The paper was a preliminary discussion which, in a full form, will be presented at a subsequent meeting of the section.

The second paper was by J. McKeen Cattell, "A Method for Determining Photometric Differences by the Time of Perception." Tests have been made upon many individuals as regards their quickness in determining differences of color by means of 200 cards painted with India ink and grading from pure white to dead black. The paper detailed the results.

The third paper of the evening was by Dr. Livingston Farrand, and was entitled "Primitive Education." It dealt especially with such moral training as is given among primitive peoples to the young. The paper was preliminary to a more extended discussion that will be presented at a later meeting.

The last paper of the evening was by Dr. Franz Boas, entitled "Results of the Measurement of the School Children of Toronto." The paper was not intended for publication.

The Academy then adjourned.

J. F. KEMP,
Secretary.

REGULAR BUSINESS MEETING.

May 4th, 1896.

The Academy met with President STEVENSON in chair. Forty-five persons present. The minutes of the previous meeting were read and approved.

The Secretary then presented nominations from the Council for the following resident members: Charles B. Alexander, S. J. Meltzer, M. D., John E. Parsons, William Hornaday, E. E. Olcott, C. A. Strong, Rush Taggart.

The Section of Astronomy and Physics then organized.

Prof. A. M. Mayer presented a paper on "A Heliostat with Small Mirrors, Giving a beam of Intense Light and Forming

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an Image at Its Focus." It consists in mounting a convex lense so as to concentrate the beam of sunlight upon one surface of a double reflecting prism, the lense being so mounted to rotate upon a polar axis as to keep the sunbeam continuously upon the mirror. A negative lense near the prism rendered the beam parallel. A second double-prism set the beam in any desired direction. The advantages of this heliostat are a very powerful beam of light which can be made to emanate from a point and from which the heat rays have been almost entirely absorbed by its passage through the various pieces of glass. It is especially adapted to work with the solar microscope. The paper was discussed by Prof. R. S. Woodward.

The following notes were presented by Mr. Wallace Goold Levison: (1) On photographs of Geisler and Crookes radiant matter tubes. Mr. Levison presented a very interesting series of photographs of Geisler and Crookes tubes taken by their own light. Many of these showed very beautifully the stratification in the Geisler tubes and the difference between the anode and cathode. He also showed a series illustrating the disturbances in the stratification produced by plunging the cathodes to various depths in water. The photographs of the Crookes tubes showed not only the fluorescent spot opposite the cathode, but showed also very distinctly the bundle of cathode rays which are always invisible to the naked eye. (2) In this connection Mr. Levison pointed out the resemblance between the succession of colors with varying pressure in Geisler tubes and the color variation in the aurora and suggested that the experiment described bare out the idea that the aurora is an electric discharge through the atmosphere at various heights and pressures. A possible connection between these phenomena and the solar corona and comets was also pointed out. (3) The third note was the description of a similar apparatus for obtaining X-ray photographs by long exposure with a small induction coil and four Bunsen cells. (4) The fourth note was descriptive of certain plates which were exhibited appearing to indicate the action of a magnet on photographic films. These were called magnetographs and were made by placing various objects directly on the photo-

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graphic film and suspending a magnet in front of them. No satisfactory explanation or theory of the results has been given. (5) In conclusion Mr. Levison pointed out certain causes which in his opinion might account for the deterioration of photographic plates, suggesting among other things X-rays from unexpected sources, terrestrial magnetism, plant organisms and gases such as sulphuretted hydrogen penetrating the boxes and injuring the plates. He suggested the improvement of enclosing the plates in soldered metal boxes. These notes were discussed by Prof Mayer and Prof. Hallock.

By permission of the Section Mr. C. C. Trowbridge read by title a paper entitled "The Use of the Hair Hygrometer."

On motion the section adjourned.

J. F. KEMP,
Secretary.

WM. HALLOCK,
Secretary of Section.

STATED MEETING.

May 11th, 1896.

The Academy met with Vice-President OSBORN in the chair. The reading of the minutes of the last meeting was postponed. The following papers were read :

ON THE VERTEBRAL COLUMN, FINS AND VENTRAL ARMORING OF DINICHTHYS.

BY BASHFORD DEAN,

Department of Zoölogy, Columbia University.

Hitherto our definite knowledge of this most interesting of American Arthrodiran fishes has been limited to the structures of the anterior body parts—the jaws and the plates of the head, "shoulder" and abdomen. It was upon these characters, as described in several species, that the inference had been made that Dinichthys was closely akin to the European Coccosteus.

But any satisfactory comparison of the relations of these kindred Arthrodirans could, it is evident, only be made when

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the endoskeletal and appendicular structures of Dinichthys should be discovered. For the vertebral column, girdles and fin structures are certainly more constant as landmarks in the differentiation of genera than are the outlines or tuberculations of dermal or dental plates.

It is now accordingly of general interest that a fossil has been found which throws unquestionable light upon the structures of the backbone and fin bases of Dinichthys. This unique specimen* was discovered in the vicinity of Berea, Ohio, by Dr. William Clark, to whose zealous studies, indeed, a large part of our knowledge of American Arthrodirans has been due. It was brought to my attention in 1894 by Dr. Clark, and was subsequently forwarded to the Zoölogical Laboratory of Columbia University for renewed study. A further courtesy of its discoverer has now enabled me to present the following description:

The fossil is contained in an oblong shaly concretion, somewhat coarser in texture—sandstone-like and lighter in color—than those commonly found in the Cleveland shales. It measures about 25 cm., occupying almost the entire length of the concretion. The appearance of the fossil is shown in the accompanying figure (Plate VII.). This, it should be explained, was prepared from a tracing of the structures displayed on the right half of the concretion, and to this drawing were added from the counterpart the posterior ventral plates, R P V and L P V, a coprolite, C, a portion of the "ventral fin," V F, and the two plates of unknown position, U. These additional structures are accordingly shown in their normal position in the fossil, but the plates R P V and L P V should be understood to overlie, not underlie, the ventro-median plate, V M.

As to the identification of the fossil as Dinichthys, a comparison of the plates, VM, RPV, LPV and AV, with those of the ventral armoring of Dinichthys as figured by Newberry† and Wright‡ leaves little doubt that these structures belonged to this genus. The plates are relatively thinner, however, than those of the types of D. terrelli and D. intermedius, but the writer finds by an examination of the plates of the type D. gouldi, Newb., preserved in the Geological Museum of Columbia, that the present specimen may be assigned almost definitely to this species.

The fossil presents for examination the following structures:

(A). Plates of the ventral armoring, AV, VM, LPV, RPV, U (?).

*The type is preserved in the Clark collection.
†Newberry, Palæozoic Fishes of North America, U. S. Geol. Surv. Monogr. XVI.
‡Wright, The Ventral Armor of Dinichthys, Am. Geol. Vol. XIV., Nov., 1894.

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(B). Notochordal area and vertebral arches, NC, NA, HA, HS.
(C). Supporting elements of the dorsal and of a pelvic fin, DF, VF, VG.

(*A*). VENTRAL ARMORING.

There is little difficulty in identifying the typical plates of the ventral armoring, and in the accompanying figure, Pl. VIII., Fig. 2, these have been arranged in approximately their natural relations.

Of the *Anterior Ventrals* the fossil exhibits but a single plate, the left, Pl. VII., AV; this is shown in visceral aspect, its anterior margin broken and weathered. Its lateral margin, like that of Coccosteus, as described by Traquair,* and like that of Dinichthys terrelli, as recently shown by Wright (op. cit.) is the thicker; and along this margin, which, by the by, is relatively wider and less incurved than in D. terrelli, pass well-marked parallel striæ. The opposing margin of the plate is thinner, and shows little trace of encircling striæ, although the weathering of the surface may possibly account for their absence. Vascular canals (Haversian), rendered more conspicuous by the weathered surface, pass directly into the plate in its antero-lateral region; from this center they diverge radially, and become most conspicuous as open furrows in the thinner peripheral parts. The plate's elongated candal end seems especially thin where it overlaps the left posterior ventral (Cf. Pl. VIII., Fig. 2, LPV).

The *Posterior Ventrals* are both shown in the fossil, Pl. VII., R P V, L P V. They are seen in visceral aspect, and appear to occupy very nearly their normal relations. Portions of these plates have been lost, but their structure is admirably preserved. The margins of the visceral surface are marked by concentric striæ, which as in all the derm plates of Arthrodirans may be regarded as rings of growth. The focus of the vascular canals is prominent in the middle region of the plate, their radiating tubules becoming most conspicuous peripherally. The middle region of the left posterior ventral has been detached, but in such a way that a portion of its outer (surface) layer has been left in position. This fragment demonstrates clearly that the surface of the ventral armor in this, if not in every species of Dinichthys, was tuberclated. These tuberculations are fine, closely arranged, and project little above the surface; they form an encrusting superficial layer and, as the specimen indicates, separate readily from the underlying table of the plate. On this account it is possible that the dermal plates of Dinichthys terrelli, intermedius and curtus have always appeared to have been lack-

* Traquair, Ann. Mag. Nat. Hist. [6] Vol. V., (1890), pp. 125–136.

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ing in shagreen-like structures, thus giving ground for the belief that these plates were deeply embedded in the ventral integument.

The *Ventro-Median* plate, Pl. VII., VM, has been retained in a fair degree of preservation. Like the neighboring plates, it exhibits its visceral aspect, and has been but little displaced. Parallel to its margins are well-marked striæ, and a series of straight vascular tubules converge toward its center. The plate's anterior end terminates in an enlarged, flat, rounded area, which appears to be the homologue of a separate plate in Coccosteus, the "anterior median ventral" of Traquair. In Dinichthys, however, this element is relatively much smaller in size. In the present specimen its surface has been greatly weathered.

Two additional dermal plates are shown in the fossil, Pl. VII., U. They appear to represent a pair of plates hitherto undescribed in Dinichthys. Of their relations little is suggested, although it is possible that they represent the antero-lateral plates of the shoulder armoring of Coccosteus. In the neighborhood of these plates the fossil has retained a large pale-colored mass, amorphous, ragged in fracture, which in character and position may well represent a coprolite. It is lacking, however, in fish fragments, and, if a coprolite, it affords no evidence of the presence in Dinichthys of an intestinal spiral valve.

Comparison of the ventral armor of Dinichthys gouldi with that of D. terrelli, as described by Wright, gives evidence that the conditions in the smaller species were by far the more generalized. (cf. Pl. VIII., Figs. 2 and 3.)

Thus, in D. gouldi, Pl. VIII., Fig. 2.

1. The anterior and posterior ventro-lateral plates correspond closely to each other in size.

2. The anterior ventro-laterals were simple oblong plates, comparatively uniform in thickness, and straight margined, *i. e.*, not crescent-shaped as in D. terrelli.

3. The relation of the anterior ventro-laterals to the posterior ventro-laterals was a simple one, the former overlapping the latter broadly and apparently loosely; there is no evidence that the overlapping portion of the anterior plates were fitted into an insunken area in the hinder plates.

4. The posterior ventro-laterals were simple oblong plates; their hinder median margins overlapping (the right possibly overlapping the left, unlike in Coccosteus), but showing no trace of the peg-and-socket suture by which they are united in D. terrelli.

5. The outer surface of the plates (posterior ventro-laterals,

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and probably the rest as well) was tuberculate as in the earliest Dipnoans and Teleostomes.

And it is further evident that the ventral armoring of D. gouldi does not differ widely from that of Coccosteus. (Cf. Pl. VIII., Figs. 1 and 2.)

(*B.*) Notochordal Area and Vertebral Arches.

The space formerly occupied by the notochord is clearly apparent in the present fossil, Pl. VII., NC. And an idea may even be obtained of the notochord's relative thickness, as it passed tailward from the region of the ventral armoring in the broad space margined on either side by the remains of vertebral arches. As nearly as the present writer can determine the proportional thickness of the notochord in Dinichthys is not widely different from that in Coccosteus, although, perhaps, slightly thicker in the former type. In neither form have any traces been found of vertebral centra.

The vertebral arches, as shown in the present fossil, Pl. VII., NA, HA, have been imperfectly preserved. The following notes regarding them may, however, be safely made: They were as numerous, relatively, as in Coccosteus; they show a similar regional differentiation, and appear to be similar in structural regards. On the other hand, they differ from the conditions in Coccosteus in being shorter and more uniform in length. Their substance, too, appears to have been frailer, and judging from the structures shown in several cases, it seems probable that these arches could not have been widely different from those of Ceratodus, *i. e.*, cartilaginous internally, the superficial layers encrusted with lime. Under these conditions the hæmal and neural structures would naturally be subject to distortion during fossilization.

The neural arches seem to have tapered distally into a neural spine. The fossil shows no evidence that this may originally have been a separate element, nor does it show that the neural arch had ever appended to it a more distal element. The hæmal arches, on the other hand, seem to have terminated bluntly and to have been capped by a separate spine-shaped element (hæmal spine?) as seen, for example, at HS in Pl. VII. It must be admitted, however, that this jointed appearance may have been due to artefact. If a normal character, the separation of the naemal spine from the arches becomes an important diagnostic character, separating Dinichthys from Coccosteus.

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(*C*). Supporting Elements of the Dorsal and of the Pelvic Fin.

The position of the basal support of the dorsal fin may be outlined in the fossil, Pl. VII., DF, although they are imperfectly preserved. In number they correspond closely to those of Coccosteus, but in other regards they appear to have been widely different; they are thus smaller and slenderer, and the elements of their proximal row, although very imperfectly shown, seem to have differed considerably from the neighboring distal elements. It is also noteworthy that the outer tips of the distal elements appear to have been the more densely calcified, so that indeed these tips could remain after the remaining portion of the element had disintegrated. Several of these separated distal ends may be noted in the fossil. The evidence now presented is sufficient to demonstrate that the dorsal fin of Dinichthys was relatively in the same region as in Coccosteus, but that it was smaller and more delicate, the latter character directly opposed to what might have been inferred on *a priori* grounds.

The pelvic girdle and the basal supports of the ventral fin are shown in the fossil, at VG and VF, Pl. VII. Their preservation is, however, so imperfect that nothing definite can be determined about them; indeed were it not that this portion of the fossil corresponds so closely in position and outline to the structures of the ventral fin and hip girdle in Coccosteus, one could hardly be justified in atttempting an identification. The writer is inclined to believe that the apparently separate elements at VF. are in reality not the basalia of the ventral fins, but artificially separated portions of the distal part of the pelvic girdle.

Fin structures in Dinichthys (terrelli) have already been described by Prof. Newberry, and figured by him in his Palæozoic Fishes (Monograph XVI, U. S. Geological Survey, Pl. VII.). His specimens, however, had been sent him without their matrix, and he could not therefore determine their exact position. They had been received from Ohio from Mr. J. Terrell, who had several times found them associated with the bones and plates of D. terrelli. These "ossified fin rays," as far as Dr. Newberry could judge from a single detached group of them, and from several fragmentary elements, were then believed to represent in part the base of the dorsal fin. The structures of the present specimens are certainly not adverse to this view of Dr. Newberry. But a reëxamination of the types by the present writer leads to the belief that they may well have been exernal fin structures.

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They certainly do not correspond to the basalia of the dorsal fin shown in the present material, although they may have represented the external rays. It is possible that they may prove to have been caudal structures.

The additions to a knowledge of the structures of Dinichthys as given in the present paper, may be summarized as follows:

I. Presence of notochordal axial skeleton, of dorsal fin and of pelvic girdle, similar to those in Coccosteus.

II. Presence of an hitherto undescribed pair of dermal plates.

III. Evidence that a pair (and probably, therefore, all) of the plates of the ventral armoring were surface plates.

A contrast of the ventral armoring of Dinichthys gouldi with the corresponding structures in D. terrelli and in Coccosteus (cf. Pl. VIII., Figs. 1, 2 and 3), leads the present writer to believe that the conditions in Coccosteus are most nearly those of the common ancestor of these three forms. And that in D. gouldi are present more generalized conditions than in the larger species. Thus in Coccosteus the plastron is composed of separate dermal plates, more or less rhomboidal in outline, and differing little from each other in size. In Dinichthys, on the other hand, these plates differ more widely from each other in size and outline, the median plates—median ventral and anterior median ventral —no longer broadly lozenge-shaped and separate, are now reduced to a single narrow lanceolate element. In D. gouldi the plates of the plastron overlap as in Coccosteus; in D. terrelli they become more widely unlike each other and are fixed together with definite sutures.

May 12, 1896.

THE HISTORY OF THE ACHROMATIC STRUCTURES IN THE MATURATION AND FERTILIZATION OF THALASSEMA.

By Bradney B. Griffin, B. Sc.

University Fellow in Biology, Columbia University.

The following observations on the eggs of the chætiferous gephyrean, *Thalassema*, were made on a series of stages collected at Beaufort, N. C., by Professor E. B. Wilson, in the summer of 1895, with a view to the investigation of the achromatic structures, and especially the centrosome in maturation and fertilization. In intrusting this material to me Professor Wilson suggested that I should first follow out in detail the history of the centrosome with special regard to its behavior

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with the various fixing agents employed. Apart from this my special object has been to determine whether that structure commonly known as the centrosome, *i. e.*, the small dark staining body at the poles of the division figure, is a permanent persistent organ, handed down from one cell division to the next, or a transitory structure present only during karyokinesis, disappearing later and re-formed at the next division. As will be seen, my results show conclusively that so far as *Thalassema* is concerned, the former is the correct alternative; and on this point my results agree with those of van Beneden and Boveri (*Ascaris*), Mead (*Chætopterus*), Wheeler (*Myzostomum*), and others who have more or less definitely attained the same result.

The present paper deals principally with the achromatic structures; the history of the chromatin the author hopes to discuss in detail in a future work.

The material included series fixed with picro-acetic and sublimate-acetic, and a few stages with pure sublimate, and with Merkel's Fluid. Of these the best results were given by picro-acetic, which gives, in most cases, faultless preservation of all the structures. In the series fixed by sublimate acetic, certain interesting differences are seen, a description of which will be deferred until the normal history of the centrosome has been considered in detail.

The eggs were imbedded in paraffine, cut into sections 2–5μ thick, mounted and stained on the slide by Haidenhain's Iron Hæmatoxylin, followed in a few cases with Congo Red to differentiate the reticulum of the centrosphere.

I desire to express my indebtedness to Professor E. B. Wilson for the numerous courtesies he has extended me during the progress of the work, and my sincere appreciation of his advice and encouragement.

The Egg Centrosome.

The earliest trace of the egg centrosomes that I have so far been able to detect was in preparations from eggs fixed about ten minutes after fertilization. They then appear as two minute dark staining granules, already distant about 90°, situated close to the nuclear membrane which is still intact though showing a slight invagination, folding, or at least a flattening next the centrosomes. This is probably caused by inwardly growing rays. At this stage the centrosomes are indistinguishable from the surrounding cytoplasmic granules, save for the minute few and short rayed aster focused at each. This fact renders the question of the origin of the centrosome extremely difficult if not

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insolvable in this form; for previous to the formation of the asters the centrosomes could not be distinguished from the numerous nuclear as well as cytoplasmic granules. This black centrosome granule seems to be the only structure at the focus of the rays, and shows no trace of a surrounding archoplasmic mass, apart from the radiating fibrillæ of the aster. As yet no chromosomes have been definitely established, though here and there are to be observed slight thickenings or bunching together of strands of the chromatic reticulum which is doubtless the prelude to chromosome formation. There is also present in this stage a large dark staining nucleolus, situated eccentricly within the nucleus. The nucleus lies very nearly in the center of the egg, and the deutoplasm is pretty evenly distributed in the surrounding cytoplasm. (Fig. 1.)

From now on the size of the asters and the number, length and distinctness of the rays steadily increases.* The nuclear membrane meanwhile becomes more and more pushed into the folds by the ingrowing spindle fibers in essentially the same manner as described by Watasé (Squid), Wheeler (Myzotomum), Braus (Salamander) and others. The deepening of the folds continues until at length the nuclear membrane commences to break apart at the apices of the folds. Through the openings thus formed the rays enter the nucleus, while the intervening portions of the membrane seem to be drawn into the polar system and pass insensibly into rays. (Fig. 2.) Typical tetrad groups, to the number of nine I believe, are meanwhile established, and before the membrane has commenced to fade a small centrosphere is differentiated about each centrosome. In some cases, at least, the latter becomes double even at this early period, by an extremely precocious division in anticipation of the second polar division.

In most cases the asters develop independently, unconnected with each other by any sort of *central spindle*. The definitive spindle finally arises by the meeting of rays from the opposite asters. In two or three cases, however, where for some reason the asters had not diverged far, but remained comparatively near together, I observed what seemed to be a central spindle connecting them, in a stage corresponding to Fig. 2. It is figured in Fig. 3. The difference is probably due to variation in the relation between divergence and growth of the asters. If great divergence takes place while the asters are yet small, as usually the case, no such "central spindle" is formed, but the appearance shown in Fig. 2 results. If, on the other hand, the

* This progressive elongation of the rays with the growth of the aster agrees with Drüner's account of the spermatocytes of the Salamander.

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asters diverge but little while their growth continues, then the state of things shown in Fig. 3 will follow.

The nuclear membrane now gradually fades away, first disappearing in the neighborhood of the asters, and the tetrad chromosomes are drawn up into the spindle. A vast amount of the chromatin is left as a very coarse stranded reticulum or skein lying in the cytoplasm, where it degenerates and finally fades away, though it sometimes persists until the first polar spindle is in place. (Fig. 4.) The nucleolus can be traced through all stages previous to the one just described. The latest period at which I have observed it was in a stage slightly later than the one figured. It then appears in the mass of discarded chromatin as a dark staining body, variable in shape and size though always considerably smaller than in previous stages.

With the arrangement of the chromosomes in an equatorial plate, the first polar spindle is completed. It lies tangentially on the periphery of the mass of discarded chromatin. The spindle now rotates through 90° and assumes a radial position. (Fig. 5.) At this stage the length of the spindle is nearly one-third the diameter of the egg. At each pole is a well defined light staining centrosphere, containing a double centrosome. The centrosphere is perfectly homogeneous and shows no trace of any darker area surrounding the centrosomes. A noticeable feature is presented by the rays. These are relatively of great length, many exceeding that of the entire spindle. Those that pierce the equatorial plane, external to the spindle, show a marked curvature toward the axis of the latter. This curvature is greater in those lying nearer the spindle. At this period the egg shows a marked polarity, which was not so obvious in earlier stages. This is brought about by the collection of the deutoplasm at the lower pole, leaving the region at the upper pole surrounding the spindle relatively free from yolk granules. A slight flattening or depression of the surface of the egg next the external aster is also to be seen the stage just described. (Fig. 5.) During the halving of the tetrad groups no change takes place in the achromatic figure until mid or late anaphase, when the two inner centrosomes diverge considerably in a direction perpendicular to the axis of the spindle, the centrosphere meanwhile elongating in the same direction.

The telephase, therefore, shows the two centrosomes wide apart, one at each pole of the now somewhat fusiform centrosphere, and the rays show a tendency to group themselves about these poles as foci. The dyads left in the egg, after the expulsion of the first polar body, lie at the outer side on the periphery of this incipient spindle, stretching in a curved row from

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pole to pole. (Fig. 6.) During the divergence of the centrosomes no trace of connecting spindle fibers is to be detected, and the interior of the elongating centrosphere appears unchanged. The appearance of spindle fibers passing from pole to pole, and the disappearance of the intermediate rays mark the establishment of the second polar spindle, the dyad chromosomes still, however, retaining their peripheral position. As yet no well defined area or centrosphere has appeared about each daughter centrosome, but the rays seem to converge directly to the centrosomes. Before or during rotation the dyad groups become arranged equatorially about the new spindle, while an extremely minute centrosphere differentiates about each centrosome. The spindle, which at first lay tangentially, *i. e.*, with the axis perpendicular to the egg radius, finally rotates into a radial position lying near the periphery. (Fig. 8.) It closely resembles in general appearance the first polar spindle, but is only one-half the size of the latter and the centrospheres are excessively minute. The curving of the rays, so noticeable in the first polar spindle, is here scarcely perceptible. In all essential features the subsequent stages are a repetition of the first polar anaphase. The second polar body is formed at or extremely near the point at which the first was expelled, since not only do the two in later stages lie in contact, but in several cases the extruding second polar globule was seen to push the first before it. The subsequent history of the polar bodies I have not as yet followed out in detail. The first in several cases was seen undergoing mitotic division. They persist until the second cleavage when they seem to be taken up bodily into the egg and absorbed by the cytoplasm.

The origin of the centrosome of the second polar spindle by division of the centrosome of the first has been observed in other forms. Thus Boveri (1) has shown that in the Heteropods the centrospheres of the second polar spindle arise by division from the inner centrosphere of the first. A stage exactly similar to my Fig. 6 has been figured and described by Mead (7) for *Chætopterus* indicating that a similar mode of origin of the second polar spindle occurs in that annelid. More recently Korschelt (6) has described the maturation in the egg of another annelid *Ophryotrocha*, from which it appears that, in mode of derivation of the second polar centrosome, *Ophryotrocha* agrees with *Thalassema*, save that in the former the centrosome is represented by a body of considerable size.

It is interesting to note that in several cases the *second* polar telophase shows the centrosome again divided and with the halves more or less diverged, as though preparing for a third

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mitosis. This incipient amphiaster, if it may be so called, never progresses so far as to show spindle fibers. A third mitosis involving the egg centrosome does not, however, occur; for soon after the above described stage and before the meeting of the pronuclei both centrosomes with their surrounding atmospheres and asters, degenerate and disappear. This doubling of the centrosome seems too orderly to be a commencing fragmentation preparatory to degeneration, and one cannot avoid the thought that it may be a reminiscence of some ancestral process such as a parthenogenetic division or possibly a "quadrille" such as Fol has described.

A somewhat later stage shows the chromosomal vesicles formed and closely crowded. All that is now left of the egg center are a few indistinct rays. A little later Fig. 10, even these disappear and the vesicles show no trace whatsoever of aster, rays, or center of activity connected with them. Moreover previous to their disappearance these radiations, in connection with the female vesicles, are seen lagging behind the latter on the side removed from the male pronucleus. The sperm center at this stage (Fig. 10) consists of two powerful asters with focal centrosomes, at the poles of a hemispherical pronucleus.

The foregoing observations show conclusively, as I believe, that the egg centrosome persists throughout all the maturation stages, but thereafter disappears. In the cleavage stages its place as directive center in cell division is taken by the sperm centrosome. The sperm asters can be traced throughout all the subsequent fertilization stages; their foci at no time show any such disturbance or sudden doubling or increase in size of the centrosomes, as would be expected did the egg center join or fuse with them.

The Sperm Centrosome.

For some time after its entrance into the egg the spermhead shows no trace of archoplasmic mass, centrosome, or radial arrangement in the surrounding cytoplasm, but lies as a large homogeneous spherical body, somewhat roughened on its periphery, and staining intensely black by hæmatoxylin. It is situated somewhat eccentricly within a surrounding clear area. In this condition it remains for some time. The first appearance of the aster is at the extremity of a small process that arises from the spermhead. In the stage figured this is directed forward toward the center of the egg, but in one or two earlier preparations it appeared to be situated at one side and directed tangentially. This fact may indicate that the spermhead ro-

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tates, as Wilson and Mathews (10) have shown to be the case among the Echinoderms. The process extends through the surrounding clear region, to the margin of the cytoplasm, where it is seen to be crowned by a minute aster with a focal centrosome similar in all respects to the egg centrosome in its earliest condition, the rays converging directly to the centrosome without any visible surrounding archoplasmic mass. A division of the centrosome which soon follows leads to the formation of a minute amphiaster still some distance in advance of the main portion of the spermhead. (Fig. 8.) By this time the process has disappeared. A "central spindle" connecting the daughter centrosomes is not demonstrable in all cases. In cases where it appears to be present, it is impossible to decide, owing to its extreme minuteness, whether it is a true central spindle or merely an accidental meeting of astral rays. In later stages it entirely disappears.

While the second polar anaphase is in progress both the sperm amphiaster and the sperm pronucleus increase in size and the latter assumes a vesicular structure and approaches the amphiaster. By the time the female vesicles are formed and aggregated, and their radiations are disappearing, we find the male pronucleus assuming a hemispherical shape with the base closely applied to the amphiaster, one centrosome and aster at each pole. (Fig. 10.) As yet no centrosphere has appeared, the rays still converging directly to the centrosomes.

Considerable variation exists in regard to time of fusion of the vesicles. In some cases they fuse extremely early, in others they reach the male pronucleus and fuse with it while still separate though closely aggregated. This appears to be related to the position of the male pronucleus at the time of the second polar anaphase. If the former is still some distance away the vesicles may have time to fuse before meeting it, but if, on the other hand, the sperm nucleus has already advanced so as to lie near the vesicles when the latter are formed they may not have time to fuse before copulation of the pronuclei. The female pronuclei or group of vesicles now applies itself to the base of the male pronucleus *between the asters*, and in all cases so far observed, fuses with it completely, giving rise to a segmentation nucleus in which there is no visible distinction between paternal and maternal chromatin. After, or even before, the wall separating the two pronuclei has faded, the chromatin is observed to have thickened at various points to form the commencement of the chromosomes. This fact renders it highly probable that there is no actual fusion of the chromatin, but that each half retains its individuality and that one-half of the resulting chromosomes are of paternal origin and the other half of maternal.

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Throughout all these stages the centrosomes are clearly traceable and at no time disappear. During the formation of the segmentation nucleus the asters as a whole become far less distinct, though they are seen to be composed of numerous extremely long rays that converge directly to the centrosomes. Even at this stage fibres can be observed proceeding inward toward the nucleus. (Fig. 11.)

The Cleavage-figure.

With the completion of the segmentation nucleus the asters again become distinct, the rays steadily increase in number and become more densely crowded as the development of the asters progresses. A small centrosphere now begins to differentiate about each centrosome The spindle fibers from each aster are now more marked, throwing the nuclear membrane into folds at each pole. At no time, however, do they show the slightest evidence of entering the centrosphere, but in all cases end centrally at the periphery of the centrosphere. The nucleus now elongates, becomes spindle-shaped, its membrane fades away at the poles before the advancing spindle fibers, while laterally it is visible for some time, forming the lateral boundary of the spindle, its two halves converging toward the poles exactly like astral rays. (Fig. 12.)

It persists thus for some time, in some cases until the process of chromosome formation is considerably advanced, but sooner or later it disappears. In the stage figured, each centrosphere contains but one centrosome occupying a central position. Before the equatorial plate is established, however, each centrosome becomes double and moves into a slightly eccentric position, nearer the outer periphery of the centrosphere. In favorable preparations each pair of centrosomes is seen to lie in the center of a body or area, distinguished from the surrounding centrosphere by staining slightly deeper with Iron Hæmatoxylin. This body, however, is in most cases extremely faint and can be made out only with difficulty. Up to this point the spindle has been steadily elongating, a phenomenon which appears to be a continuation of the process of divergence of the centrosomes, subsequent to the division which gave rise to the sperm amphiaster. (Compare Figs. 8–12.)

The fully formed mitotic figure (Fig. 13) is closely similar in appearance to that of *Toxopneustes*, as described by Wilson (11). In *Thalassema*, as in *Toxopneustes*, each aster contains an immense lightly staining centrosphere, sharply distinct from the dense outer crown of astral rays. In the former, however, the distance between the outer peripheries of the centrospheres is

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over one-half the diameter of the egg, a much greater ratio than that figured for *Toxopneustes* (12) wherein the length of the spindle similarly measured is seldom a third of the egg diameter. The reticulum occupying the interior of the centrospheres is exceedingly fine and close. It stains very faintly with Hæmatoxylin, though quite deeply with congo red. The centrosomes are now seen to be exceedingly near the outer peripheries of the centrospheres. In some preparations the surrounding darker area seems to have already faded away, in others it is distinguishable (faintly it is true) not only in this stage, but during the early anaphase as well, though even then it soon disappears. In most cases no trace of rays can be detected within the centrospheres, though sometimes what appears to be a few short rays can be seen converging toward the centrosome when the latter is near the periphery. It is noteworthy that these appear only when the centrosome is near the periphery, and that they occur on the outer side only of the centrosome. These rays, however, appear much finer than the astral rays and to resemble in their staining properties the substance of the centrosphere. The astral rays can be readily seen to branch out distally and become continuous with the cytoplasmic reticulum, exactly as described by Wilson (10) in *Toxopneustes*. Moreover the granular nature of the rays and of the cytoplasmic reticulum is clearly demonstrable. In these features they are exactly similar to the homologous structures in the maturation spindles.

The splitting and divergence of the chromosomes now follow (Fig. 14), during which the centrosomes, undergoing no change save perhaps a slight further divergence of the daughter centrosomes, persist on the outer periphery of each centrosphere, as two dark staining granules. In this condition they remain until about mid anaphase, when (Fig. 15) a few rays may be seen to be focussed about each, making on the outer periphery of each centrosphere a minute and rather indistinct amphiaster. The old rays still persist. This amphiaster, as will be seen, is the precocious preparation for the second cleavage.

The next stage (Fig. 16) shows the centrosomes further separated and with a small though well defined aster about each. The rays of these asters converge directly to the centrosomes with no certain trace of surrounding centrosphere. In this stage it would be impossible to distinguish the centrosomes were it not for the asters. The centrosphere now ellipsoidal in shape has been growing less distinct, its interior taking a darker stain and more nearly resembling the cytoplasm. Except in the region of the second cleavage amphiaster, it is still surrounded

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by the old rays still converging to the old center. The divergence of the chromosomes is accompanied by a gradual elongation of the old spindle, so that the outer periphery of each centrosphere comes to lie nearer the egg periphery. By the time the chromosomes have reached the edge of the centrosphere each becomes converted into a minute vesicle, and the centrosomes of each amphiaster have further diverged, while their rays have increased in number and distinctness. (Fig. 17.) The old rays are now mostly indistinguishable, though they persist for some time on the sides of the former centrosphere, still converging to the old center. Boveri has figured (1) just such a persisting convergence of rays to a previous center, in *Ciona*, just previous to formation of the first cleavage figure.

The vesicles are now drawn up into the region of the former centrosphere, where they gradually fuse, forming at first a lobate nucleus. The newly formed amphiaster lies on the outer periphery of this nucleus, the two asters separated about 90° ± (Fig. 18.)

It might be noted that from the first each aster seems to develop, independent of the other, around its focal centrosome; there seems to be no persistent and genuine "central spindle" connecting them. What seems to be a central spindle in Fig. 17 is, I believe, merely a transitory, non-significant structure due to the meeting of rays from the two asters. It later disappears, with the complete fusion of the vesicles.

The nucleus now rounds out, all trace of the component vesicles disappearing, while the asters continue to diverge until they occupy opposite poles of the nucleus. Even before the definite position has been reached, spindle fibres commence to grow in toward the nucleus. The subsequent history, so far as traced, *i. e.*, until commencement of the second cleavage anaphase, is but a repetition of that of the first. At the poles of the completed vesting nucleus, spindle fibres grow in, folding the membrane, which later first fades away at these points. The nucleus becomes spindle-shaped; a centrosphere is formed around the centrosomes, which very early divide and become surrounded by a darker area within the centrosphere. In the equatorial plate stage, or slightly later, the centrosomes commence to migrate toward the outer periphery of the centrosphere, where the dark area fades away. Further than this I have not followed it.

Effect of Fixing Agents.

Sublimate-acetic (80% sublimate solution and 20% acetic acid), though in general affording fine fixation of both chromatic

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and achromatic structures, yet causes the deutoplasm spheres to lose their staining power more or less completely, while picro-acetic or pure sublimate brings them out sharply, causing them to stain intensely black with Hæmatoxylin. This seems to hold true in a measure for the centrosomes, since in many cases they fail to appear after treatment with sublimate-acetic. This agent also appears to swell up the centrospheres to a considerable extent, giving them in the fully-formed cleavage figure a diameter greater than the width of the spindle at the equatorial plate, while after picro-acetic their diameter is considerably less than that of the equatorial plate. In other respects, however, they present an appearance closely similar to that described by Wilson (11) in *Toxopneustes* after the same reagent. He then obtains a large reticulated centrosphere staining red by Bordeaux or Congo red, surrounded by a dense crown of blue staining astral rays, and in which "*there is absolutely nothing that can be identified as a centrosome.*" This renders it not impossible, as Wilson has himself expressly pointed out,* that the centrosome may be here likewise present within the centrosphere in the same form as in *Thalassema*. This is, perhaps, strengthened by the fact that both Boveri (2) and Reinke (9) have described in the Sea urchins a centrosphere more or less closely similar to that of *Toxopneustes*. On the other hand, it should be noted that in numerous preparations of the sublimate series the egg of *Thalassema* still retains traces of the behavior of the centrosome, so easily made out in the picro-ascetic series. Thus in the fully formed cleavage figure up to mid anaphase there is often seen a circular hyaline region, occupying the same relative position within the centrosphere as the cloudy area surrounding the centrosomes in the corresponding stages of the picro-acetic series. Within this area I observed in some cases two dark staining granules in every respect similar to the centrosomes, while in other preparations these could not be demonstrated. Moreover, in certain poorly preserved and much distorted picro-acetic preparations exactly such a clear area could be seen surrounding the centrosomes. In the sublimate-acetic series it was extremely rare to find a trace of the newly formed peripheral second cleavage amphiaster, though occasionally during and subsequent to the telophase the minute asters could be made out, with their centers, however, swollen up and bereft of centrosome. None of these appearances are described for *Toxopneustes*. It might be interesting to add that in *Sphærechinus* Hill obtains (5), after using sublimate-acetic, a distinct

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centrosome in the first cleavage figure. Von Rath (8) also describes a similar state of affairs in the Echinoderms.

Both v. Beneden and Boveri have given detailed descriptions of the morphology of the polar systems, centrosome, sphere, rays, etc. Between the accounts of these two investigators there exists considerable discrepancy which has been carefully considered by Häcker (4). In *Thalassma* it would seem that morphologically the minute dark staining granule is equivalent to Boveri's "centriole," the cloudy surrounding area to his "centrosom," the centrosphere to the "hellem Hof," and the crown of astral rays to his "archoplasm." Furthermore, my "centrosphere" seems to correspond to the centrosphere described by Strasburger in Vegetal Karyokinesis. Functionally, however, the black granule ("centriole") is here the true centrosome, since it alone of all the elements of the polar system persists and multiplies by division. We have seen that the rays centrosphere and cloudy area, which are in turn differentiated about the centrosome, are formed only during the stages immediately preceding the establishment of the chromosomes and equatorial plate, and commence to break down the moment the anaphase is fairly under way. They subsequently degenerate *in situ* and disappear completely, while the centrosome, unaccompanied by any surrounding archoplasm mass, migrates to the periphery of the centrosphere, where it sets up a new series. From this fact, as well as from the extreme minuteness and constancy in size of the centrosome, it would appear that the rays, centrosphere and cloudy area are probably to be looked upon as differentiations of preëxisting cytoplasmic material, or possibly the product of a specific form of metabolic activity set up in the cytoplasm by the centrosome, which disengages the forces at work in mitosis.

ZOÖLOGICAL LABORATORY COLUMBIA UNIVERSITY,
May, 1896.

[Since the above went to press there has appeared an extremely interesting article by Kostanechi and Wierzejshi (Ueber das Verhalten der sogen. achromatische Substanzen im befruchteten Ei. Nach Beobachtungen an *Physa fontanalis*. Archiv. f. Micr. Anat. Bd. 47 H. 2 April, 1896). From the figures and accounts of these authors it appears that *Physa* very closely resembles *Thalassema*. In the precocious division of the centrosome, the origin of the second polar spindle, the absence of a quadrille, the division of the second polar centrosome previous to its disappearance, the formation of the sperm amphiaster, and in some cases the curving of the rays—in all these points the

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correspondence is almost complete. Moreover, during midana-phase these investigators obtain two small amphiasters at the poles of the first cleavage figure in all respects similar to those of my fig. 16. In *Physa*, however, there is no *large* centro-sphere, and consequently no previous peripheral wandering of the centrosomes.—June, 1896.]

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EXPLANATION OF PLATES.

Figs 1, 2, 4, 5, 8, 9, 10, 11, 12, 17 and 18 were drawn by Prof. Wilson and the writer; the remainder were drawn by the writer.

PLATE IX.

FIG. 1. The egg ten minutes after fertilization, showing the minute asters and their focal centrosomes, also the large black nucleolus.

FIG. 2. Somewhat later stage several tetrad groups have been already formed.

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FIG. 3. The same stage, showing variation in relation of asters to nucleus.
FIG. 4. Much later stage. The tetrad groups have now been established, leaving a mass of discarded chromatin. The sperm head is shown at ♂.
FIG. 5. First polar spindle during halving of tetrads. Sperm head at ♂.
FIG. 6. First polar telophase. Sperm head and aster (♂).

PLATE X.

FIG. 7. Second polar spindle, still tangential in position. Slightly later than Fig. 6.
FIG. 8. Second polar spindle. Spermhead with amphiaster (♂).
FIG. 9. Second polar telophase, showing centrosomes divided. Sperm-head and amphiaster (♂).
FIG. 10. Shortly before copulation of pronuclei, showing male pronucleus (♂) with powerful asters, and the female vesicles (♀) devoid of asters.
FIG. 11. Copulation of pronunclei.
FIG. 12. Somewhat later stage, segmentation nucleus elongating.

PLATE XI.

FIG. 13. Fully formed first cleavage figure, showing centrosomes already divided and surrounded by the darker area, nearing the periphery of the centrosphere.
FIG. 14. Commencement of anaphase. Centrosomes or periphery of centrosphere.
FIG. 15. Stage just previous to mid anaphase, minute amphiaster forming about the centrosomes.
FIG. 16. Mid anaphase, amphiaster elongated.
FIG. 17. Vesicles previous to fusion.
FIG. 18. Vesicles fusing.

ANATOMY OF THE EAR OF THE DOG-FISH (GALEUS CANIS.) PRELIMINARY PAPER.

BY WARREN H. EVERETT.

This work was begun at the Marine Biological Laboratory, Wood's Holl, Mass., during the summer of 1893, at the suggestion of Prof. Howard Ayres, of the University of Missouri. It was continued at Hamilton College under the supervision of Prof. A. D. Morrill, and brought to its present state of completeness at the Biological Laboratory of the New York University.

The auditory capsule of the dog-fish (Galeus canis) is situated on either side of the head just outside of the brain cavity, the anterior wall of the capsule forming the posterior wall of the orbit. A line drawn from the posterior corner of the eyelids would touch the most anterior part of the ear.

The capsule consists of a mass of hyaline cartilage, lined in-

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side and out with a layer of small calcareous plates. The cavity within the capsule is known as the capsular or perilymphatic cavity, and incloses the internal membranous labyrinth or ear. The cavity is an irregular chamber with canals arising from it. In the freshly killed animal this cavity contains a thin, transparent and watery substance, the perilymphatic fluid. There may also be seen a network of fine connective tissue fibres which connect the membranous portions of the ear with the walls of the cavity, holding them in place and at the same time supporting the blood vessels of the ear. Where the membranous parts are in close contact with the walls of the cavity the fibres form a cushion between the membrane and the wall. These fibres are especially distinct in preserved material.

The internal ear consists of a body made up of two parts closely united and three curved tubes that arise from the body in different planes. The divisions of this body portion are called the sacculus and the utriculus, and the tubes given off, the semi-circular canals. The sacculus gives off a small, rounded body, the lagena. The recessus utriculus is near the proximal end of the utriculus and under the ampullæ of the anterior and horizontal canals. Figs. 1–5 show these parts as seen from the side, back, above, front and behind. The transverse and vertical diameters of the ear are approximately equal. The axial diameter is somewhat greater.

Let us now look at each part of the ear separately, beginning with the sacculus (s.) and utriculus (u.) as the most prominent and as occupying a central position around which the other parts are arranged.

Sacculus.

The sacculus (s.) is the largest division of the ear. It lies upon the ventral and inner wall of the body part of the capsular cavity, occupying a little more than one-half the whole space. It may be compared in shape to a flattened sack or flask, the sides of which project more posteriorly than anteriorly. The upper part of the sacculus is marked by a depression that extends somewhat diagonally across the dorsal surface. (* * Fig. 5.) The portion above this depression is the utriculus (u.). If we examine the inner or ventral wall of the sacculus (s.) we find no line of separation. The sacculus seems to pass into the ductus endolymphaticus (d. end.), gradually narrowing down until it becomes a small tube not more than 1 mm. in diameter. This tube, which is the ductus endolymphaticus proper, passes upward just in front of the connecting tube of posterior canal (p. c. t.), inclines a little toward the median

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plane, and upon reaching the top of the ear bends suddenly toward the median plane, passes through the wall of the capsule and enters an oblong depression in the top of the skull. The duct now expands into a flattened sack which makes four bends and opens externally close to the occipital portion of the lateral line. Whether the ductus endolymphaticus connects or communicates with the lateral line system, I cannot say. One dissection gave evidence that such was the case and also that a nerve communicated with the terminal pore, but as yet I have not been able to make control dissections.

From the dorsal wall of the main body chambers of the capsular cavity there projects downward a piece of cartilage which is firmly attached to the dorsal wall of the sacculus (s.) near the center. In the vicinity of the lagena (l.) there is also a point where the wall of the sacculus is closely attached to the wall of the capsule.

Lagena.

The lagena is an outgrowth from the posterior part of the sacculus (s.). It is a small rounded sack projecting downward paralell to the median plane. It extends about 1 mm. below the lower surface of the sacculus. It seems to be formed by a constriction in the sacculus as well as by an outgrowth of its posterior wall. The lagena presents more and greater variation than any other part of the ear.

Utriculus.

The utriculus (u.) is an elongated flattened tube extending from the anterior ampulla (a. a. Figs. 1 and 5) across the upper part of the sacculus. Then curving upward it becomes thicker and broader and continues upward until it connects with the horizontal and anterior canals. As before noticed, the utriculus (u.) is on the dorsal wall of the sacculus above the diagonal line of depression (** Fig. 5), and rests on the dorsal or outer wall of the ductus endolymphaticus. The utriculus communicates with the sacculus by means of the canalis utriculo-saccularis, which is a long slit-like opening. There is no communication between the utriculus and the ductus endolymphaticus except through the sacculus or recessus utriculus (r. u.), because the partition which forms the base of the utriculus, and also the lower lip of the opening between the utriculus and sacculus, lies upon and adheres closely to the dorsal wall of the ductus endolymphaticus.

Sinus Utriculus.

The upper part of the utriculus (u.) is somewhat thicker and

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broader than the utriculus proper and is called the sinus utriculus (sin. u.). Its position is such as to form a nearly vertical portion of the ear. The horizontal canal enters this sinus at about the middle of its posterior wall. The anterior canal enters the top of the sinus, which is reduced in size and somewhat flattened in the plane of this canal.

Recessus Utriculus.

At the anterior end of the sacculus, immediately under the ampullæ of the anterior and horizontal canals (a. a., h. a., Fig. 1), and touching the anterior end of the utriculus and also a portion of the ventral wall of the utriculus, is a rounded body a little longer than broad and a trifle flattened dorsally. This rounded body is the recessus utriculus (r. u.). It communicates with the utriculus by means of the ductus-utriculi, a small slit in the upper inner wall of the recessus utriculus. It also communicates with the sacculus by a broader opening, the canalis recessus saccularis. The ductus-utriculi is situated just above the canalis recessus saccularis.

Semicircular Canals.

Arising from the sacculus and utriculus are three nearly semicircular tubes. These tubes are from 1 to 1½ mm. in diameter and very regular. Each tube is inclosed in a capsular canal. They arise in three distinct planes and receive their names from their positions. The one that lies in a vertical plane forward and outward is called the anterior canal. The one that lies in a vertical plane backward and outward is called the posterior canal. The third canal lies in a plane nearly horizontal to the body of the ear. The planes of the first and second canals make an angle of 107° with each other.

The plane of the anterior canal makes an angle of 37° with the median plane. The plane of the posterior canal makes an angle of 36° with the median plane. These angles are the averages obtained by actual measurements made after the top of the capsule had been removed and before the canals had been in any way disturbed. Out of more than twenty-five measurements, the greatest variations found in any angle was less than 1°; very few measurements showed any variations. Fig. 6 is a traced copy made from a photograph of the ear and brain. It shows the relations of the ear to the brain and eye, also the angles made by the anterior and posterior canals. The third canal extends outward from about the center of the body of the ear in a plane slightly oblique to the frontal plane.

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This is called the horizontal canal. The proximal end is in close relation with the proximal end of the anterior canal at the recessus utriculus (r. u.); while the distal end enters the sinus utriculus through its posterior wall a little above the plane of the canal.

The posterior canal (p. c.) is almost completely separated from the body of the ear. At the proximal end just after the canal bends inward and forward is an enlargement, the ampulla of the posterior canal; from this ampulla, inclosed in a capsular canal is a thin membranous tube which connects the ampulla with the distal end of the canal. This tube is the connecting tube of posterior canal (p. c. t.). It is much larger than the rest of the canal and completely fills the capsular canal.

The only communication which the posterior canal has with the body of the ear is a small, short tube, the ductus canalis posterioris (d. c. p.). It arises from the middle of the connecting tube, passes under the distal end of the horizontal canal, and enters the sacculus pointing toward the lagena.

Ampullæ.

The proximal ends of all the canals are swollen into vesicle-like bodies having the side farthest from the center flattened at the point where the nerve enters. These enlargements are the ampullæ (a. a., p. a., h. a.).

The ampulla of the anterior canal is directly above the utriculus (u.) and opens freely into it. The ampulla of the horizontal canal is connected with the utriculus by means of a short tube, the ampullar tube (a. t.). It enters the utriculus under the posterior part of the anterior ampulla. The ampulla of the posterior canal has been mentioned. It is larger and longer than either of the others.

Nerve Supply.

The auditory or eighth cranial nerve passes from the brain and enters the capsular cavity in the same plane as the lower surface of the brain and at nearly right angles to the axis of the body. Upon entering the capsular cavity the nerve (n.) comes immediately into contact with the anterior portion of the sacculus (s) just under the recessus utriculus (r. u.). At this point the nerve divides into two branches. One branch supplies the sacculus, lagena and posterior ampulla; the other the recessus utriculus and the ampullæ of the anterior and horizontal canals. The former branch is made up of two parts: the ramulus posterioris, that supplies the ampulla of the posterior canal, and the ramulus sacularis, which supplies the ventral part of the

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sacculus. This ramulus branches and spreads over the ventral wall of the sacculus. Part of the fibres of this ramulus extend to the papilla acustica lagenæ. From about the middle of the ramulus posterioris (r. p. a., Fig 2) and directly under the anterior part of the connecting tube of the posterior canal (p. c. t.), two small branches are given off, the ramuli of the macula neglecta (m. n.). These ramuli pass upward to the connecting tube of the posterior canal. The larger ramulus clasps the upper side of the tube with brush-like endings. The smaller ramulus clasps the under side and the fibres of the two interlace. The other main branch of the auditory nerve turns upward toward the recessus utriculus and branches, sending off the ramulus recessus to the ventral wall of the recessus utriculus. A little beyond, the main branch divides and sends ramuli to the ampullæ of the anterior and horizontal canals.

BIOLOGICAL LABORATORY,
NEW YORK UNIVERSITY, May, 1896.

EXPLANATION OF THE FIGURES.

REFERENCE LETTERS.

s.	Sacculus.
u.	Utriculus,
r.u.	Recessus utriculus.
l.	Lagena.
a. c.	Anterior Canal.
p. c.	Posterior Canal.
h. c.	Horizontal Canal.
a. a.	Anterior Ampulla.
p. a.	Posterior Ampulla.
h. a.	Horizontal Ampulla.
d. end.	Ductus endolymphaticus.
d. c. p.	Ductus canalis posterioris.
p. c. t.	Connecting tube of the posterior canal.
sin. u.	Sinus utriculus.
* *	Line of depression between s. and u.
a.t.	Ampullar tube.
n.	Auditory Nerve, 8th Cranial Nerve.
r. p. a.	Ramulus to posterior Ampulla.
m. n.	Macula neglecta.

PLATES XII., XIII., FIGS. 1–5. Show different views of the complete membranous ear of the right side. FIG. 6, View of the canals and their relation to the brain and eye.

FIG. 1. The membranous ear as seen from the outside at nearly right angles to the side of the head and a little above. It shows the shape and position of the sacculus (s.), utriculus (u.), lagena (l.) and their relation to each other: also the position of the ampullæ with respect to the canals and the recessus utriculus (r. u.). d. c. p. represents the small connecting tube between the connecting tube of the posterior canal (p. c. t.) and the sacculus (s.).

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FIG. 2. The membranous ear as seen from the inside at right angles to and on a level with the head. It shows the position of the ductus endolymphaticus (d. end.) and its relation to the sacculus (s.), utriculus (u.) and the recessus utriculus (r. u.). It also shows the position of the utriculus (u.) with respect to the recessus utriculus (r. u.) and the ampulla of the anterior canal (a. a.). The two dotted lines that extend from the ramulus of the posterior ampulla to the ductus canalis posterioris (d. c. p.) show the course of the ramuli of the macula neglecta. (m. n.) marks the macula.

FIG. 3. The membranous ear as seen from in front. It shows the overlapping of the connecting tube of the posterior canal (p. c. t.) over the sinus utriculus (sin. u.). It also shows the position of the nerve (n.) which supplies the recessus utriculus (r. u.) and the ampullæ of the horizontal and anterior canals (h. a.) (a. a.).

FIG. 4. The membranous ear as seen from behind. It shows the posterior canal (p. c.) and the tube (d. c. p.) that connects it with the sacculus (s.), lagena (l.) and sinus utriculus (sin. u.) as seen from a posterior direction. It shows the angle of the horizontal canal (h. c.) with respect to the body of the ear. Also a general end view of the sacculus (s.). It also shows the ampullar tube (a. t.) of the horizontal canal (h. c.).

FIG. 5. The membranous ear as seen from above. It shows the large curve made by the horizontal canal (h. c.) and the shape of the ampulla (h. a.) of the horizontal canal (h. c.) together with the angle at which it enters the utriculus (u.) at the base of the anterior ampulla (a. a.). The darkened line from the horizontal and anterior ampullæ represents the diagonal line of depression (**) which marks the separation of the utriculus (u.) and sacculus (s.). This view also shows the angle between the posterior and anterior canals (p. c.), (a. c.).

FIG. 6. This is a drawing traced from a photograph of ear, eye and brain. It shows the angles made by the anterior and posterior canals with the axis of the head and with each other. Also the position of the ear as referred to the eye and brain.

THE PACIFIC SALMON WITH NOTES ON THE HABITS OF THE YOUNG.*

BY TARLETON H. BEAN.

The natural distribution of the salmon family covers all the principal divisions of the world, within arctic and temperate limits, except South America, and even in that continent man has attempted to supply what nature omitted.

The river trout and sea trout of Great Britain have been acclimatized in Tasmania and New Zealand, and the former has been successfully introduced into many waters of the United States. The rainbow trout of California is now thriving in many of the Eastern States, in which it has been planted, as well as in Mexico, Japan and Continental Europe. The quinnat

* Read April 13, 1896, before the Biological Section of the New York Academy of Sciences.

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salmon of California is now reared with certainty in some parts of France and Germany.

Ichthyologists now recognize about one hundred valid species in the salmon family, including the white fish, the *inconnu* or *nelma*, *ai* of Japan, *lenok* of Siberian rivers and lakes, the black-spotted river trout, the red-spotted charr and the Pacific and Atlantic salmon.

In North America a species of trout is native in the Sierra Madre of Mexico, in Chihuahua, near the boundaries of Durango and Cinaloa. This is the most southerly species known. The range northward is coincident with the limits explored by man. In the United States the eastward distribution of black-spotted trout was checked by the plains of the middle region, which present conditions unfavorable to salmon life. The Atlantic ocean formed an impassable barrier to their westward migration and their want of adaptation to Arctic life prevented invasion of Atlantic streams from the north.

The salmon family includes some small members, for example, the capelin, the oulachon, or candle fish, the smelts; and such very large ones as the common whitefish, the *inconnu*, the lake trout, the Atlantic salmon and several of the Pacific salmons.

The genus of Pacific salmons, *Oncorhynchus*, was established by Dr. Suckley, in 1861, in the Annals of the Lyceum of Natural History of New York. It was based upon the *Salmo Scouleri* of Richardson, now known as the *gorbuscha*, or little humpback salmon, the smallest of the known species unless we regard Kennerly's salmon as a distinct form, and not a variety of the red salmon dwarfed by landlocking.

Five well marked species of *Oncorhynchus* are recognized at present and these inhabit the North Pacific Ocean, from which they ascend rivers at various periods of their lives, but chiefly when about to spawn. The identification of the species, fortunately, is not difficult and may be accomplished by reference merely to the number of scales in a longitudinal series, branchiostegal rays, anal rays and gill-rakers—all external characters except the last.

One of the salmon, the little humpback, has more than 200 scales in the lateral line, and is at once distinguished thereby. Two of them have about 150 scales, the quinnat and the dog salmon, and they are readily separated by the number of the branchiostegals and anal rays. Two others have about 130 scales and may be recognized easily by the great difference in the number of gill-rakers, the silver salmon having 23, while the red salmon has 35 or more.

The red salmon can be identified immediately by means of its

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gill-rakers, which are far more numerous than in any other species. It was by reference to this character that the young individuals before you were easily made out.

The following brief key will serve to distinguish the species:

Scales 200 or more..... .Gorbuscha.
Scales about 150;
B. 17; A. 16..... .....Chouicha.
B. 14; A. 14..... .....Keta.
Scales about 130;
Gill rakers 23.....Kisutch.
Gill rakers 35.....Nerka.

In the eight small examples here shown the gill-rakers vary from 33 to 38, and the lengths, to end of middle caudal rays, from $5\frac{3}{4}$ to $6\frac{5}{8}$ inches.

The great size of some of the species of *Oncorhynchus*, the enormous abundance of individuals, and the surpassing value of the products of the salmon fisheries unite to increase the interest of the biologist and the political economist in this noble group of fishes.

To illustrate, the average weight of the quinnat salmon is above 20 lbs., and individuals weighing 100 lbs., are authentically recorded. At St. Paul, Kadiak, in 1880, Mr. B. G. McIntyre had one that weighed $87\frac{1}{2}$ lbs., without its viscera; the fish must have exceeded 100 lbs.

The abundance of the fish is best shown by reference to the statistics of the canning industry, and on this point I quote from Dr. Smith, W. A. Wilcox and other recent authorities. Dr. Smith says:

"The chief objects constituting the products of the west coast fisheries are salmon, cod, herring, flounders, rockfish, smelts, whales, fur seals, crabs, shrimps and oysters. The salmon are nearly as valuable as all of the other products combined. Chief among the fishery industries of the Pacific States is the canning of salmon, which is prosecuted on a large scale in California, Oregon, Washington and Alaska. In 1892, 56 canneries were in operation. These utilized 81,487,993 pounds of salmon, having a value of $2,376,037, from which 1,118,098 cases of canned fish, each holding 48 one-pound cans or the equivalent, were prepared, the market value of the canned goods being $5,294,032."

W. A. Wilcox, in Report, U. S. Fish Commission, 1893, states that: "From 1866, the year in which salmon canning began on the Columbia river, to 1893, inclusive, the gross weight of the salmon utilized for canning was over 658,000,000 pounds, and

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the value of the pack was over $59,000,000. The salmon salted, consumed fresh locally, or shipped fresh to other parts of the country, aggregated 192,000,000 pounds, making the total output of the Columbia 850,000,000 pounds, worth $66,000,000. If the total salmon catch of the Columbia river during that period could be loaded into railroad cars, 42,500 ordinary freight cars would be required to contain the fish, which would make a solid train over 280 miles long."

During the five years beginning with 1889, the number of pounds of salmon utilized in Alaska was 275,262,240, an average of over 55,000,000 pounds a year.

The British Columbia salmon pack in 1895 was 566,395 cases of 48 pounds each. At the rate of 12 fish to a case this represents 6,796,740 salmon.

It is safe to assume that fully 20,000,000 of salmon are utilized annually by canning and salting establishments of the Pacific coast, and these represent chiefly only two of the five species. Vast numbers of salmon are consumed also by whites and natives in the region inhabited by the fish. Upward of 150,000 salmon have been caught in a day at a single fishing station in Alaska.

The species represented by the greatest number of individuals are the red salmon and the little humpback.

The sea-going habit of the salmon makes the study of its marine life history impracticable, and there are no stations on any of our salmon streams at which continuous observations are made. There is not even a fishery at sea for any of the species, as there is in the Baltic in winter for the Atlantic salmon. Under such conditions our knowledge of the fish comes slowly and imperfectly, the sources of information being limited chiefly to fish-breeding establishments wherein salmon are kept under a species of domestication.

The following remarks upon the migrations of the Atlantic salmon are found in Day's *British and Irish Salmonidæ*:

"Respecting the salmon, trout and charr, the most diverse opinions have been and are still held as to whether their ancestry was marine or fresh water.*

"The fact must not be lost sight of that, if salmon ever depended for their entire subsistence on the fresh water they ascend, the amount of food they would require would be so great in a river as to constitute a nuisance and cause pollution were it left unconsumed.

*Parnell, 1838, remarked there is no doubt that the true abode of the salmon is in the sea, for as soon as it has entered the rivers it begins to deteriorate in condition, the scales lose their brilliant silvery lustre, and the flesh becomes soft and pale.

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"Salmon on entering rivers, as a general rule, deteriorate in quality, similarly to what has been shown takes place in sea fishes prevented migrating to the ocean, unless under peculiarly favorable conditions; therefore it becomes a question of what is the effect on salmon debarred from going to the sea.

"During the summer months the salmon roams along our coasts in search of food, and may be found close in shore many miles from where any fresh water enters the sea, loitering in estuaries and also at the mouths of rivers up which it purposes ascending.

"The fish culturist is aware that their eggs will not hatch if deposited in salt water.

"Salmon are anadromous, entering our rivers chiefly for the purpose of perpetuating their race. During their youth they live and feed in fresh water; as they grow older they descend as smolts to the sea, from whence after a time they return as grilse and salmon to the rivers; thus the waters they select for their residence differ from each other in specific gravity, taste, temperature and products.

"Most of the male salmon pars kept at Howietoun had milt in November, 1883, when 2 years and 8 months old. At the age of 3 years and 8 months all of these fish seemed ready to breed, and young were bred from their spawn. Consequently, descending to the sea prior to depositing ova is not a physiological necessity for young salmon."

Upon the breeding habits of the Atlantic salmon Dr. Günther makes the following statement in his *Introduction to the study of Fishes:*

"The salmon offers a most remarkable instance of irregularity as regards the age at which the individuals arrive at maturity. Shaw has demonstrated in the most conclusive manner that those small salmonids, which are generally called parr, are the offspring of the salmon, and that many males, from 7 to 8 inches long, have their sexual organs fully developed, and that their milt has all the impregnating properties of the seminal fluid of a much older and larger fish. No parr has ever been found with mature ova."

Speaking of the same species, Mr. Frank Buckland stated before a Parliamentary Committee in 1877 that a salmon does not breed every year, but once every three years. Mr. Chas. G. Atkins has published observations on the Atlantic salmon in Penobscot River, showing it to be a biennial spawner.

The marine life of the Alaskan salmon is practically unknown, and even the age at which they become sexually mature and return to the rivers to spawn is uncertain. Some ichthyologists

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have held to the theory that the salmon mature in three or four years from the time they first leave the rivers, assuming that they go to sea when one year old. This theory is apparently in conflict with the fact that individuals of the same species differing greatly in size enter the rivers simultaneously.

As a guide to the age at which the quinnat salmon becomes sexually mature we have the important experiments of Dr. Jousset de Bellesme in the Trocadéro Aquarium, Paris, and in ponds elsewhere in France. He states that many individuals are mature when three years old, and that they reproduce as well in fresh water without going to sea as they do under the usual conditions in their native waters. At the age mentioned they weigh from thirteen to fifteen pounds.

From recent observations at the Karluk River, Kadiak Island, Alaska, it appears that young red salmon frequently return from sea with the adults, and sometimes ascend the river at least a short distance. Mr. Barling, who manages a fishery at Karluk, called my attention to the return of young salmon with the adults in the following letter concerning the specimens exhibited:

SAN FRANCISCO, CAL., Jan. 9th, 1896.

DR. TARLETON H. BEAN, N. Y. AQUARIUM, CASTLE GARDEN, NEW YORK, N. Y.

Dear Doctor: In the matter of the young salmon sent to you by Mr. Brommage; they were taken out of our nets in the early spring of last season (1895). For many seasons past I have noticed the small fry in surprising numbers standing inshore with the adults, and while I was satified that they were small salmon, I could not so positively state ere this, on account of not being able to catch them before they escaped through the larger meshes. I was enabled to furnish you the few which I sent by backing up the nets with the small-mesh seine; at the time we caught over 1,000 small salmon and only 900 adults.

Some of my friends on the (Karluk) river always maintained that these small fish were trout, and even now some are hardly satisfied. I will state, however, that these small fry salmon are not to be seen in numerous quantities after August 10th.

I have always maintained ever since I have been in Karluk that the fish we catch are not all Karluk bred fish, being merely attracted inshore by the fresh waters from the Karluk river. This year (1895) was not as much so as in many years past, but that was caused by the extreme lengths of the nets driving the salmon outside the range of the inner buoys.

Yours very truly,

(Signed) H. J. BARLING.

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In 1889 the writer saw a few young male salmon at Karluk in company with schools of adult fish seeking to enter the river. This probably occurs annually, but the return of red salmon measuring only six inches in length in such numbers and with such regularity as noted by Mr. Barling is a circumstance of very great interest. There may be some doubt whether these young fish have really entered upon their sea life, but the observer states positively that they were "standing inshore with the adults," and his testimony is entitled to credit.

This species, the red or blue back salmon, is one in which the migratory habit is strongly developed; it ascends rivers to a distance above one thousand miles from the ocean, to spawn around the shores of deep, cold lakes and in their tributaries, preferring waters whose highest temperature rarely exceeds 55 degrees Fahrenheit. We know something about the spawning habits of this salmon and others of the same genus, but its marine life is a sealed book, and even its going and coming are about as little known as its geological age. The necessity of systematic and continuous observations upon this highly important economic family of fishes is obvious.

NEW YORK AQUARIUM,
BATTERY PARK, NEW YORK, April 13, 1896.

STATED MEETING.

May 18th, 1896.

The Academy met, with President STEVENSON in the chair. About twenty-five persons present. The minutes of the last meeting were read and approved.

The Section of Geology and Mineralogy was at once organized.

The first paper of the evening was by Mr. Heinrich Ries, entitled "Notes of a Trip Through the Marble Quarries of Western New England and Eastern New York." Mr. Ries sketched out the geology and geographic distribution of the limestone quarries examined along the Hudson River and Lake Champlain on the northward trip, and the marble quarries in the Green Mountains and Berkshire Hills on his return south. His remarks

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were copiously illustrated by the lantern and by many beautiful specimens. The paper was discussed by Messrs. Martin, Dodge and Kemp, to whose remarks the speaker replied.

The second paper of the evening was by J. F. Kemp, on "The Great Quartz Vein at Lantern Hill, Mystic, Conn., and its Decomposition." The speaker described the vein as being about 400 feet in width and at least 1,200 feet in length. Its northern extremity forms the summit of Lantern Hill, about 500 feet above sea level. This portion is of hard milky white quartz. The southern extension of the vein forms Long Hill. It is lower in altitude and largely composed of less pulverulent quartz, which, however, perfectly preserves the comby structure of the quartz vein. It consists of innumerable interlocking masses of quartz crystals. It is but slightly iron-stained in a few spots. It is so soft that it can be crumbled between the fingers, and is easily dug with pick and shovel without any blasting. The vein strikes north about 15 degrees east and cuts squarely across the laminations of the gneiss. It is one of the largest quartz veins known in the East and is of very pure silica. Samples from the crumbly portion range from 98 to 99.4 per cent. of SiO_2. A few rare scales of some micaceous or chloritic mineral are practically the only other materials present. Under the microscope the powdered quartz appears quite fresh, and exercises a vigorous influence on polarized light. Some prism faces of quartz crystals show etched figures, but in general the evidence of corroding alkaline solutions is hard to find. The speaker was therefore led to refer the pulverulent character of the vein to the effects of a faulting or crushing movement, although on the spot he inferred the action of some corroding alkaline solution, presumably magnesian. The paper was discussed by Messrs. Dodge and Hovey.

The third paper of the evening was by J. F. Kemp, and was entitled: "The Pre-Cambrian Topography of the Adirondacks." The speaker mentioned the curious outliers of Cambrian and Ordovician strata that had been discovered far up in the mountains at long distances from the main outcrops that skirt the mountains at lower levels. The strata lie in valleys in the

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metamorphosed crystalline rocks, which valleys represent beyond question the old Pre-Cambrian river valleys which were filled with sediment by the encroaching sea of Potsdam and Ordovician times. Lake George is the largest example of this kind, and contains remnants of Potsdam sandstone and Trenton limestone in the southern portion. The valley of Trout Brook, which lies just west of Rogers' Rock, at the north end of Lake George and is separated from it by a high intervening ridge of gneiss, contains two outliers of Potsdam sandstone of a few acres in extent. In the valley of Putnam's Pond, in the western part of Ticonderoga township, there is another outlier of Potsdam sandstone. Both these latter are shown on the map of Ticonderoga which accompanies the speaker's report on this region to Prof. James Hall, which report was published in 1895. Another isolated area of Calciferous limestone is found on Schroon Lake, under Schroon Lake Post Office. It is a few acres in extent and the exposed rock is about 75 feet thick. It is about 850 feet above tide at its upper point. Down the lake and river valley it is nearly forty miles to the next Cambrian outcrop, which is below Hadley. The speaker also cited the little outlier on the Newton Mountain, near Wells, on the Sacondaga River, and the fact that the Cambrian and Ordovician sediments on the west side reach short distances into the areas of crystalline rocks and along the river valleys. He stated that all the outliers on the east had a uniform northeasterly strike and a dip 10 to 20 degrees to the northwest. He remarked that they occur in the valleys of streams which are now notably sluggish, and explained this slow movement by suggesting that these streams flow in Pre-Cambrian valleys, which were in that time reduced nearly to a base level. He referred this parallel strike and dip to the later faulting and tilting of the strata in this region. Remarking upon the undoubted presence of faults in the development of the topography he emphasized the evidence that this early erosion acted long before the time of fossiliferous sediments. He added that the old river valleys had been in part determined by the presence of crystalline limestones. The paper was discussed by Messrs. Dodge and Hovey.

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The last paper of the evening by Messrs. L. M. Luquer and H. Ries described an area of Augen-gneiss near Bedford, N. Y. It was read by Mr. Luquer and will appear in full in the TRANSACTIONS. The gneiss appears to have been originally a granitic rock that has been extensively crushed and sheared out into the "augen" structure. The original quartz has been mostly comminuted, but the Carlsbad twins of orthoclase have remained as "augen." The paper will appear in the *American Geologist*.

The paper was discussed by Dr. E. O. Hovey, who cited the case of the sheared Eisenach quartz-porphyry, in which the feldspars have been crushed, but the quartzes have been drawn out.

Mr. G. F. Kunz mentioned the following items as the meeting closed.

A meteoric stone weighing 31 ounces was seen to fall by Mr. J. F. Black, April 9th, 1896, at 6:15 P. M., on his farm nine miles east and one mile north of Ottawa, Kansas. This meteorite contains iron particles throughout and is of the characteristic stony variety.

A remarkable nugget of native silver, weighing 448 ounces troy, was lately found five miles from Globe City, Pinal county, Arizona. The mass is a water-worn nugget, slightly oval, very compact, and on its surface is bright silver-white, showing that it is made up of strings of crystallized silver, whereas the interior of the mass contains more or less cerargyrite. It has been presented to the Lea collection of American minerals of the United States National Museum.

New Zealand promises, mineralogically, to be a country of surprises, as many interesting things are gradually being brought to light by the agate hunters from Oberstein, Germany, who are visiting it. Recently they have discovered some immense masses of rolled, rutilated quartz, weighing from ten to thirty pounds each. The masses are penetrated by crystals of rutile, red, brown and yellow, many inches in length and of the fineness of hair. Occasionally the rutiles occur very sparingly; then again they are in such profusion as to give the entire mass the appear-

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ance of being a matted mass of hair. One mass of thirty pounds was entirely of this character. A fifteen-pound mass contained a dozen or more crystals of rutile forty-five cm. in length and from one-half to two mm. in diameter. Magnificent crystals of amethyst have also been found, one of which is entirely of gem-cutting material and weighs 550 pennyweights or 27½ ounces troy. Topaz, blue and white, is found in the same localities.

J. F. KEMP,
Secretary.

FAUNAS OF THE PARADOXIDES BEDS IN EASTERN NORTH AMERICA, NO. 1.

BY G. F. MATTHEW.

CONTENTS.

	PAGE.
Introduction	192
Minute Crustaceans	194
Genus Agnostus and its species	207
Genus Microdiscus and its species	236

The following article is a contribution to a revision of the faunas of the Paradoxides beds as they are developed in eastern North America. The region where these beds are found is spread along the Atlantic sea-board from New Foundland to eastern Massachusetts, and it is not known that the genus Paradoxides existed west of the Braintree basin in that State.

In this article only the smaller crustaceans, including two genera of trilobites, are treated off. But these small fossils are as valuable for the correlation of horizons as the larger species, for they were as sensitive to a change of conditions as those, and tell the story of the sub zone which they mark with as great certainty as Paradoxides itself. In fact, they are even of higher value for this purpose, as a small piece of shale will contain a fully characterized example.

In the author's former paper * an outline was given of the Cambrian system in eastern North America and its faunas, so that it seems unnecessary here to do more than call attention to the sub-divisions of the Paradoxides sub-faunas as they are developed in this region. We know of the occurrence here of

*The Protolenus Fauna. New York Acad. Sci., Vol. XIV., p. 101.

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four of the six sub-faunas into which the Paradoxides fauna is divided viz:

The Sub-zone of *P. lamellatus* Hartt (cf. *P. Oelandicus*).
" " " *P. Eteminicus* (cf. *P. rugulosus*).
" " " *P. Abenacus* (cf. *P. Tessini*).
" " " *P. Davidis.*

The first of these sub-zones is the oldest Paradoxides fauna of which we have any knowledge, and so far has been recongnized in two countries only, viz., Sweden in Europe, and New Brunswick in eastern Canada. It is characterized by Hartt's species, *P. lamellatus*, easily recognized by the interrupted, raised plates on the front of the glabella; the varieties of Conocoryphe and Ctenocephalus which occur here have more hispid tests than those of the next sub-zone. This sub-zone is the home of *Microdiscus Dawsoni* and *Liostracus tener*,* and occurs in Sweden.

The next sub-zone, that of *P. Eteminicus*, has a wide range on both sides of the Atlantic, but seems to be most fully represented in the southern regions of the area over which the genus Paradoxides was spread. It is the most prolific band of the Paradoxides beds in New Brunswick, and is the only sub-zone recognized in Massachusetts, France and Spain; the species cited by Walcott indicate its presence in Newfoundland; it occurs in Wales as the Solva group (or in that group); it is present in Bohemia, and is sparingly represented in Sweden in the "Exsulens Kalk."

The third sub-zone, that of *P. Abenacus* (a species closely allied to *P. Tessini* of Sweden and *P. Bohemicus* of Bohemia), is represented in New Brunswick by a well-marked fauna, in which Ptychopariæ and Solenopleuræ abound. *Microdiscus pulchellus* is a characteristic species of this sub-zone, and it is a stronghold of the genus Agnostus. This sub-zone is doubtfully present in Newfoundland,† but it is in full force in Norway, Sweden and Bohemia.

The highest sub-zone so far recognized in America is that of *P. Davidis*, which has a full representation at several localities in Newfoundland. It is characterized by the genus Anopolinus, by the species *Microdiscus punctatus* and by large Agnosti, including examples of the Section Lævigati. This sub-zone is

*Walcott catalogues this species from Newfoundland as occurring in his zone A at Manuel Brook, but the species quoted by him as associated with it there, are of the next sub-zone.

†I have spoken of this horizon being present there (Trans. Roy. Soc. Can., Vol. IV., p. 150) at Chapel Arm, but the presence of Anopolinus seems rather to indicate the next sub-zone. In Mr. Walcott's Zone B. of the Manual Brook Section there is a mixture of the species of the second and fourth sub-zone, but the presence of species of the intermediate zone does not distinctly appear.

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well marked in Wales, where the species *P. Davidis* was discovered, and it is fully represented in Sweden.

The other two sub-zones of the Paradoxides beds are not known to be represented in America, and so far as the author knows, have not been recognized outside of Scandinavia. That of *P. Forchammeri* is contained in the Andrarum limestone, a very rich repository of Cambrian forms, where the Paradoxides fauna may be said to have culminated. The higher of these two sub-zones contains only the dying remnants of this fauna and is known as the Zone of *Agnostus lævigatus*. Rare remains of a Paradoxides related to *P. Tessini* have been found in it. I. D. Wallerius has lately described a number of new genera, species and varieties from this sub-zone in Sweden.

The following is in brief the range of the American subfaunas of Paradoxides so far as known:

Sub-zone of P. lamellatus—New Brunswick only.

Sub-zone of P. Eteminicus—New Brunswick, Newfoundland and Massachusetts.

Sub-zone of P. Abenacus—New Brunswick and Newfoundland (doubtfully in the latter province).

Sub-zone of P. Davidis—Newfoundland only.

Descriptions of genera and species.

Phyllopoda?

As compared with the Phyllopod crustacean of the Olenus and higher zones the fossils described below are very small. Their minuteness is an obstacle to the study of their characters, for there has been sufficient molecular movement in the shales in which they are imbedded to obscure the surface markings of such delicate fossils as these. They are supposed to be crustacean on account of the long, straight hinge line and weak umbones and their defined bordering rim.

Lepiditta.*

Obliquely semi-circular or semi-elliptical bivalves, wide on the anterior half of the valve and having a long, straight hinge line; umbones in front of the mid-length of the hinge, low or but moderately elevated.

Lepiditta alata (Plate XV., figs. 1*a* and 1*b*).

Lepiditta alata, Trans. Roy. Soc. Can., Vol. III., pt. iv., p. 61, pl. vi., figs. 16, 16*a*.

* Trans. Roy. Soc. Can., Vol. III., pt, iv., p. 61.

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Valves obliquely semi-elliptical, about one-third longer than wide; hinge line straight, umbo less than one-third from the front of the valve. Tumid part of the valve occupying about one-third of its length and about one-half of its width; valve flattened toward the anterior and posterior ends. A faint narrow rim is traceable around the outer edge of the valves.

The cast of the right valve has a triangular umbonal prominence, about one-third from the front; the prominence is limited in front by a sharp and deep furrow, placed at right angles to the hinge line, and extending thence toward the base of the valve; the umbonal elevation is somewhat hollow in the middle, where it bears a sharp, narrow ridge, which is directed toward the posterior margin, at an angle of 50° from the hinge line; a faint furrow connects this ridge with the point of the umbo.

The outer surface of the valves of this species is marked by numerous concentric striæ, and by two faint radiating furrows, extending on each side of the tumid part of the valve to the basal margin.

The sharp median ridge and connected furrow, seen in the cast of the right valve of this species, are similar to those on the dorsal valves of some Brachiopods, but the position of the umbo separates it from that class of molluscs.

Length, 1 mm. Width, $\frac{3}{4}$ mm.

Horizon and Locality. In the fine, gray shales of Div. 1. c, at Hanford Brook, St. Martin's. Infrequent.

Lepiditta curta (Plate XV., fig. 2).

Lepiditta curta, Trans. Roy. Soc. Can., Vol. III., pt. iv., p. 61, pl. vi., fig. 17.

Obliquely semi-elliptical and about two-sevenths longer than wide; hinge line nearly straight; umbo depressed, less than one quarter from the front of the valve. Valves flattened toward the base and posterior end, the anterior margin has a flattened, depressed rim; and the front of the rim in the two valves was apparently connected by a triangular piece not bounded by distinct sutures.

The interior of shell has roughened zones or undulations concentric to the umbo.

This organism is not unlike the crustaceans of the genus *Estheria*, but its resemblance to the preceding species, in form and hinge characters, indicates a generic relation.

Length, $1\frac{1}{2}$ mm. Width, $1\frac{1}{4}$ mm.

Horizon and Locality. In the fine dark shales of Div. 1.d^1, at Porter's Brook, St. Martin's. Rare.

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LEPIDITTA AURICULATA (Plate XV., figs. 3*a* and 3*b*).

Lepiditta auriculata, Trans. Roy. Soc. Can., vol. xi., pt. iv., p. 99, figs. 2 *a* and *b*.

Only a mould of the left valve is known. This is purse-shaped and has a short ear at each end of the hinge line. There is no marginal rim. Two grooves in the mould at the hinge line show that the hinge had two oblique plates towards the posterior end.

The surface of the mould is highest a short distance below the hinge, whence it descends gradually to the posterior margin, where the valve is nearly flat. This mould also shows faint, parallel ridges, concentric to what is supposed to be the anterior end. Faint lines mark off three quadrate spaces, near the hinge, parallel to the long plate, and corresponding in position to the upper seal-like marks of *L. sigillata* of the Protolenus Zone (Div. 1 *b*. *3*).

Size.—Length, 4 mm.; width, 3½ mm.; height of one valve, about ½ mm.

Horizon and Locality.—In the fine olive gray shale of Div. 1 *c* at Hanford Brook, S. Martin's.

This species is something like that which Mr. C. D. Walcott refers to *Nothozoe Vermontiana*, but has a longer hinge line and is more triangular in form; it is also much flatter than that species. Its long hinge line and hinge plates show it to be of the genus Lepiditta.

OSTRACODA.

After the abundance of individuals and the variety of form in the Ostracoda of the Protolenus Fauna, the few found in the Paradoxides bed is somewhat of a surprise. Perhaps the Agnosti so common in the fine shales of bands *c* and *d* usurped the place of the Ostracoda.

PRIMITIA, Jones.

This genus is represented by more than one species in the rocks of the St. John group, and the author proposes to describe here a very tumid form, of which a few individuals have been found.

PRIMITIA ACADICA (Plate XV., figs. 5*a*–*c*).

Primitia Acadica, Trans. Roy. Soc. Can., vol. iii., pt. iv., p. pl. vi., figs. 22, 22 *a* and *b*.

Outline of the valves elliptical-oblong, with but very slight

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projection at the extremities of the hinge line. The valves slope down in all directions to the margin, and the form is so symmetrical that it is difficult to ascertain which is the upper and which the lower side of the valve; but the side on which an obscure marginal fold is found, is supposed to be the lower side. It is also difficult to say which is the anterior and which the posterior end of the valve; one end has a low tubercle and a shallow pit, while the other end is plain; this distinction may be used for the purpose of locating the characters of the inner surface of the test, as seen on the mould of the valve.

The center of the valve is marked by a distinct circular depression, apparently a perforation of the test: from this point a faint medium furrow extends toward the tuberculated end, where it fades out in the shallow pit existing at that end of the valve; this pit is larger than the circular depression at the center of the valve, but differs from it in having no defined margin; beside this larger pit, but nearer to the margin of the valve, is the tubercle above referred to; it is low, somewhat pinched up at the sides, and elongated in the direction of the larger axis of the valve. The slope of the sides of the valve near the margin is nearly vertical, and the marginal fold is very feeble and obscure.

The surface of the valve is granulated, but the granulations are more distinct on the inner than the outer surface; the inner surface is more brilliant than the outer.

This Primitia resembles in form and size the Silurian *P. transiens*, Bar.; its apparently perforated disc recalls another Bohemian species, *P. perforata*, Bar.; in this species the perforation and tubercle are situated near the hinge line, but in ours near the axis.

Length, 3½ mm.; width, 2 mm.

Horizon and Locality.—In the conglomerate-limestone band, Div. 1.c^1, at Porter's Brook, St. Martin's.

In his article on the Olenellus Fauna, of Washington county, New York,* Mr. C. D. Walcott has described a peculiar Entomostracan with a flexible test under the name of *Leperditia (I.) dermatoides* with the remark, "It may be that this species should be referred to a new genus." This fossil resembles one which the author has had in his hands for some time, undescribed. The peculiar wrinkling of the test (under pressure?) separates these fossils from all other Cambrian Ostracoda, and they are here placed in a new genus.

*Fauna of the "Upper Taconic" of Emmons, in Washington county, N. Y., by C. D. Walcott. Am. Jour. Sci., vol. xxxiv., Sept., 1887.

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ALUTA, n. gen.*

Small bivalves similar in form to Aparchites (oval or ovate), but having a soft, flexible test, and a fine somewhat distinct punctation of the surface. There is no marginal fold or a very narrow one.

ALUTA FLEXILIS, n. sp. (Plate XV., fig. 4.)

Oval about one-half longer than wide, and having a very narrow rim. At the anterior upper corner is a tubercle (ocular?) enclosed by a shallow furrow. Towards the back on the upper part of the valve (in the only example known) is a broad, shallow, circular pit; irregular undulations impress the surface of the valve elsewhere.

Soulpture.—Minute, rather distinct punctures.

Size.—Length, 3½ mm.; width, 2½ mm.

Horizon and Locality.—A calcareous band in Div. 1. c^1 at Porters Brook, St. Martin's, N. B. Scarce.

This species in the position of the ocular (?) tubercle resembles *Primitia oculata* of the Protolenus Fauna, but the form of the shield is different. The species is also near Walcott's *Leperditia dermatoides*, which, although figured as ovate (if one may judge by the description), include oval forms as well; that the author makes no reference to an ocular tubercle, so we find it necessary to made a specific description.

The flexible wrinkled test causes this fossil to be overlooked as the embryo of some trilobite, but there is no trace of an axial ridge.

CIRRIPEDIA.

While skeletons of creatures referred to this group of crustaceans have been found in considerable numbers in the Cenozoic and Mesozoic rocks they are in lessened numbers in the earlier deposits; and they are more difficult to recognize on account of their wide departure in the detail, of structure from existing types. Nevertheless we now find Cirripedes recognized as members of all the great faunas from the Ordovician onward, but the writer is not aware that any remains referable to these creatures have been reported from faunas antecedent to the Ordovician; he, however, believes that such remains are present in the Cambrian rocks and proposes to describe herein such as appear to have belonged to Cirripedes.

None of these occur contiguous to each other as to suggest the remains of one individual such as enabled Dr. Henry Wood-

* Aluta leather.

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ward to describe Turrilepas, or J. M. Clarke Strobilepis, or C. L. Faber Lepidocoleus, or J. Barrande Plumulites, but when similar objects are found in the Cambrian system no doubt these genera will throw light upon them.

The remains found in the Cambrian rocks of eastern North America are only scattered plates of the exoskeleton, and they are described largely with the object of inviting attention to the plates of this kind, not at all rare in some layers of the fine shales of the Lower Cambrian, which appear to be referable to Cirripedes. Of the genera mentioned above Plumulites appear to be recognizable in certain plates found in the Paradoxides beds of Newfoundland.

Plumulites Barrande.

In 1846 Barrande observed in the Ordovician rocks of Bohemia some peculiar plates of sub-triangular form and strongly ribbed transversely, which he called Plumulites. Eleven years later he found plates of this kind grouped together in such a way as to show the kind of animal to which they had belonged. In 1864 Prof. Reuss, in connection with a memoir on the Lepadidæ of the Oligocene of Germany and chalk of Gallicia, took occasion to point out that the Plumulites of Barrande were remains of Cirripedes.* In 1865 Dr. Woodward referred the valves from the Silurian beds of Dudley, Eng., which de Koninck had called *Chiton Wrightianus* to the Cirripedes under the name of *Turrilepas*. Thus by degrees the proper zoölogical position of these peculiar valves or plates, usually found loose and scattered in the shales of the Paleozoic rocks, came to be recognized.

Barrande's description of Plumulites is somewhat diffuse, and has been summarized by Zittel as follows:† Body elongated, resembling a pine cone, clothed with 4–6 (or more) longitudinal series of scaly plates. The plates are covered by strong transverse striæ, somewhat in relief, and have a triangular form; the median series are ordinarily distinguished from the lateral by their more convex form, and by the presence of a median keel. Barrande also found a peculiar, more oval valve in which the striæ encircled the upper end, which valve he called *valve fenéstré*.

Plumulites has been found in the Ordovician (where it was first recognized) of Bohemia and Ohio, and similar plates in the Silurian of England and the Devonian of New York; it has not hitherto been reported from the Cambrian.

The presence of so highly differentiated a class of Crustaceans

*Syst. Silur. Bohême vol. i., Supp. p, 566.

† Traité de Palæontologie. Zittel and Barrois. vol. ii., p. 533.

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almost at the beginning of Cambrian time is a proof, if any were wanted, of the very early origin of the Crustacean stem; and the rarity of plates that are found in the Paradoxides beds are sufficient to show that we are as yet but very imperfectly acquainted with these ancient types of Cirripedes.

Barrande found the triangular valves of Plumulites three-lobed, by zones diverging from the apex, each having its peculiar sculpture. In describing these valves we propose to follow his nomenclature, the two slopes being designated respectively the convex and concave sides, and the third side (by which the valve was attached) the base.

PLUMULITES MANUELENSIS, n. sp. (Plate XV. fig. 7.)

A triangular plate with curved sides, one concave, the others convex, rather blunt at the apex, somewhat straight along the base. A band different in elevation from the rest of the surface of the plate traverses it from apex to base and is nearest the concave side. There are about fourteen strongly marked transverse ridges traversing the plate, parallel to the base.

Sculpture.—Fine striæ (about four to a ridge) on the transverse ridges.

Size.—Length, 4 mm.; width, 3½ mm.

Horizon and Locality.—Soft gray shales of Div. 1 d^2, at Manual Brook, Conception Bay, Newfoundland. Scarce.

This resembles in shape Barrande's *P. compar* of the Ordovician of Bohemia, but is straighter along the base and more strongly arcuate in outline above the base.

It is with great hesitation we refer the following genus to the Cirripedes as possibly representing the terminal plate of some such form as Strobilepis, or anchylosed plates similar to the terminal pair in Lepidocoleus; but it seems as likely a relation as any other that has been suggested.

STENOTHECA Salter.

This genus was proposed by Mr. J. W. Salter (published by Dr. Henry Hicks, in 1872), to include a minute corrugated shell, found in the Menevian group in Wales. It was described as a "curved shell, a small wide form, with lines of growth strongly marked on its surface." The only species figured is *S. cornucopia.*

The genus is represented in the St. John Group at one locality by numerous examples from the horizon 1d. in a fine, dark shale. The little cones of this genus are always flattened, inequilateral, and usually have a more or less rigid band along

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the back. Though shorter and wider these objects are not unlike plates of Plumulites, not only do they have the same sharp, transverse ridges, but a similar arched band extends across the middle, from the apex. This genus when described was placed by its author among the Pteropods, but if I am right in having referred to it certain small fossils of the Paradoxides beds, there would seem to be features indicating affinities with the Crustaceans, and especially with the ancient Cirripedes, rather than the Pteropods.

Stenotheca had thin calcareo chitinous shells similar to the tests of trilobites, sharply raised ridges parallel to the lower border; the apical angle was bounded by two sides, one of which was convex and the other concave. The convex side is called dorsal, and the concave ventral, the third side is the aperture or base.

STENOTHECA CONCENTRICA. (Plate XIV., fig. 1.)

Stenotheca concentrica, Trans. Roy. Soc., Vol. III., pt. iv., p. 59, pl. vi., fig. 11.

Amended description. Outline of the compressed fossil rudely lenticular, the dorsal and ventral slopes being together equal to the strongly arched apertural margin. The apex varies from a bluntly rounded form to one which is prolonged into a short triangular point. For about one-third from the apex the surface has irregular undulations, about seven in number, concentric to the apex, and the rest of the test on the ventral slope about eight strongly marked ridges, concentric to the apex; these ridges are increased on the dorsal slope to the number of twelve or thirteen by the intercalation of additional ridges in the dorsal third.

Sculpture. The surface appears to have minute pores and is ornamented with linear ridgelets which have a roughly parallel and sometimes anastomosing arrangement. The most typical form of ornamentation is a chevron or zigzag arrangement of minute ridges, visible only with a lens, and most marked on the outer part of the shell; these chevron lines sometimes cross two of the concentric ridges before turning and usually run angling across the ridges. The chevron sculpture varies to an irregular wavy arrangement of ridgelets, and that to a more or less linear grouping, which is the usual appearance of the ornamentation at the apex: occasionally straight lines on the primary ridges, alternate with wavy or somewhat zigzag lines in the hollows between. Another occasional variety of the sculpture is that of irregular wavy ridgelets crowned by little tubercles along the summit of the ridgelets; this gives the effect of a cancellated surface.

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Size.—Height of the summit of the dorsal curve above the aperture, 3 mm. Length of chord of dorsal curve, 3½ mm. Length of aperture, 4½ mm.

Horizon and Locality.—In the fine, dark gray shales of Div. 1 d.[1], at Porter's Brook, St. Martin's. Not infrequent.

This species may be compared with *S. Cornucopia* Salt. of the Menevian Group, in Wales; it differs in having a wider aperture and more strongly arched dorsal slope.

Six years ago a close examination of the surface characters led the author to refer this object (and its genus) to the Crustacea, chiefly from its punctate surface and from the fact that the sculpture showed more distinctly on the inner surface than the outer. The shell substance was also found to be calcareo-corneous, like that of the trilobites and other Crustaceans.

Var. RADIATA. (Plate XIV., fig. 2.)

Stenotheca radiata. Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 57, pl. vi., fig. 12.

Outline lenticular, more strongly arched on the apertural than the dorso-ventral side; dorsal slope about three times as long as the ventral; apex larger and more prominent than in the type; ventral slope more concave; a sulcus about one-third from the dorsum, arching from the apex to the base, usually delimits the dorsal zone from the rest of the plate. There are about five irregular, concentric ridges on the apical part and ten more distinct and regular ones on the rest of the plate.

Sculpture.—Differs from that of the type in the general absence of the chevron pattern (though in a band extending along the middle and at the outer margin this pattern sometimes appears), but generally the arrangement of the ridgelets is irregularly linear.

Size.—Usually somewhat smaller than the type.

Horizon and Locality.—In the gray shales of Div. 1 *c* at St. John; rare; also in the dark gray shales of Div. 1 d^1, at St. Martin's; more common.

The example of this variety from Div. 1 *c* is smaller than those from Div. 1 d^1, and has striæ radiating from the apex.

A comparison of these little plates with the triangular plates of Plumulites will show that they are much alike, the essential differences being the doubling of the plate in Stenotheca, its broader aperture and the insertion of additional ridges near the dorsum. The Cambrian fossils have the same sharpness and close opposition of the ridges, and in a less distinct degree the radial banding from the apex. Though we noted the points of

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resemblance in composition and sculpture between these plates and the tests of trilobites some years ago, we did not then suspect them to be parts of Barnacles, and it was only after finding the plates of another species (*S. triangularis*) in intimate relation to the detached plates hereafter described as Cirripodites that we were led to suspect that they might be parts of Barnacles, and possibly such a hollow caudal plate as Dr. Clarke figures for Strobilepis. If we admit this, however, we must also be prepared to allow that while this caudal plate was of calcareo-chitinous composition the lateral plates of the same creature were thicker and calcareous.

Another possible explanation of these little plates is that they correspond to the dorsal row of small conical plates such as is seen on Strobilepis, but this seems less likely on account of their comparative thinness and flexibility.

Among the fossils of the St. John group which the author in previous papers has assigned to Stenotheca there are two types, that just described and another chiefly characteristic of a lower horizon. It is true that all these minute fossils have certain characters in common, as the compressed conical form, the strong ribbing of the surface and the thickened dorsal band. But they have also points of difference, for in the forms described below the ribs (except in one) do not increase in number on the dorsal side; they are more distant from each other, and there are pores or perforations at their extremities; these pores or holes form a row along the dorsal ridge and sometimes also along the ventral.

The acquisition of better examples of *Stenotheca triangularis* than were in hand when this form was described, has led the writer to conclude that there are important differences between it (and some others described with it) and the typical Stenothecæ, enough to constitute specific, if not generic differences between them, if they were complete organisms; but as they are possibly only parts of organisms it is unnecessary to make any generic distinction until the general structure is known.

In the first examples studied it was not observed that the surface visible was not the outer surface of the test, but the surface of the mould of the interior, and the "long cylindrical apex" described and figured is really an internal tube in the apex of the cone.

STENOTHECA TRIANGULARIS. (Plate XIV., figs. 4*a* and 4*b*.)

Stenotheca triangularis, Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 58, pl. vi., figs. 5 and 5 *a*.

Stenotheca triangularis, Trans. Roy. Soc. Can., vol. viii., pt. iv., pp. 133, 134.

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Amended Description.—Form conical with an oval base and bluntly pointed apex. Viewed laterally the cone has a dorsal edge moderately convex, and a ventral edge slightly concave; the base is straight for two-thirds of its length and turned up at each end. The orifice of the cone is a flattened oval twice or three times as long as wide; the side of the cone is encircled by about six undulations of growth which arch upward around each end, corresponding to the curving basal margin. The cone has in its apex a short, annulated tube, about as long as the space between two of the transverse ridges of the surface. The upper two-fifths of the cone is thickened, and between this part and the base the cone has four perforations along the dorsal slope, and there are perforations (four?) also along the ventral slope. On the inner surface of the cone there are sharp, engirdling grooves corresponding to the rounded ridges on the outside, and opposite the dorsal and ventral perforations these grooves, where they meet from the opposite sides of the cone on its inside, are enlarged into a cup-shaped cavity.

Sculpture.—The rounded ridges of the surface are each traversed lengthwise by about six striæ, visible only with a lens.

Size.—Height 4½ mm; length of base 5 mm.

Horizon and Locality.—Fine grey shales of Div. 1 c^2, at St. John and Hanford Brook, St. Martin's. Infrequent.

This fossil has a thicker and firmer test than the two preceding kinds. The perforations recall those seen on the appendages of crustaceans as for instance those of Phyllopods, figured by Barrande,* and it appears probable that they are the points of attachment of mobile spines. Clarke figures a row of such in Strobilepis, but not as being connected with the terminal plate.

STENOTHECA NASUTA. (Plate XIV., figs. 6*a* and 6*b*.)

Stenotheca nasuta, Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 58, pl. vi., fig. 13.

Amended description.—Conical, subtriangular in side view, with deeply concave ventral slope and convex dorsal slope. Orifice of the cone strongly arched. As preserved in the shale there is a smooth raised band both on the dorsal and ventral slope, that on the former being wider; in the space between are about six rounded concentric ridges, parallel to the base.

Sculpture.—The surface is smooth, or nearly so, except on the dorsal band, where a number of faint striæ, concentric to the apex, are made visible by a lens.

Size.—Height, about 2½ mm.; length of base, 3½ mm.

*Systeme Silurien de Boheme, vol. i., supp., pl. 19, figs. 6, 8, 10, &c.

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Horizon and Locality.—Fine gray shales of Div. 1 *c.*, at Hanford Brook, St. Martin's, N. B., Canada. Rare.

Other examples of this form show the apex to be acute. Bosses on the surface indicate that the transverse grooves of the interior terminate near the dorsal margin in a cup-shaped enlargement similar to that of *S. triangularis*, but no perforations of this margin have been detected. Both the dorsal and ventral zones of the shell are thickened, and the concentric ridges scarcely show there.

STENOTHECA HICKSIANA. (Plate XIV., fig. 3.)

Stenotheca Hicksiana, Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 56, pl. vi., fig. 14.

Amended description.—Conical, subtriangular, with strongly arched convex slope, and a concave slope which is strongly curved near the apex, but is straight for the lower two-thirds; the base is nearly straight for two-thirds of its length, but curves upward toward the convex slope; apex not known. The cone is compressed and carries on its side about two ridges on the concave side and five on the convex, owing to intercalation of additional ridges; perforations of the shell opposite some of these ridges, on the dorsal line.

Size.—Height, 3 mm.; length of base, $3\frac{3}{4}$ mm.

Horizon and Locality.—Dark grey shales of Div. 1. *d.* [1] at Porter's Brook, St. Martin's N. B., Canada. Rare.

The comparatively few ridges ally this form with the succeeding ones.

CIRRIPODITES n. gen.

Small calcareous plates of peculiar contour and relief have from time to time been found in the beds which carry the remains of Eocystites; these plates are of such form that they do not appear to be of this genus, and the author has come to regard them as the covering plates of one or more species of Cirripedes. A symmetrical plate is rare among them, but they are usually characterized by one or more low keels with the surface somewhat depressed on one side of the keel and elevated on the other; many of them also have a deep furrow at one side, transverse to the keel. In their thickness and calcareous composition they resemble plates of Eocystites, to which some of them may belong.

Complete skeleton unknown. The remains consist of small, thick, calcereous plates, usually asymmetrical in form, smooth, but having growth lines along the margin. The following are the chief variations in form :

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Type A, Plate XIV., Figs. *a* and *b*.

Oval plates, usually rather flat, having a strong ridge lengthwise, and often a more obscure, obliquely transverse ridge. The form is not a true oval, and is usually more angulated on one side than the other.

Size.—Length, 6 to 8 mm.; width, 4 to 6 mm.

Type B, Plate XIV., Figs. *c* and *d*.

Semi-ellipsoid plates. These also are nearly flat and have a slight furrow along the straight side. From near the center at one side faint furrows radiate toward the rounded margin. Some of these plates have two long sides nearly parallel.

Size.—Length, about 8 mm.; width, about 4 mm.

Type C, Plate XIV., Figs *e* to *h*.

Roughly semi-circular plates, with or without a flange on the straight side. Between the flange and the body of the plate is a deep furrow; body of the plate elevated and having an umbo which overhangs the furrow and from which a low ridge extends toward the rounded, often emarginate or obtusely pointed opposite margin. Usually the plate is depressed on one side of the keel and elevated on the other, and there are sometimes obscure subsidiary ridges radiating from the main keel or ridge. The flange is usually wider at the sides, and reflected backward, or emarginated in the middle. These resemble the peripheral plates of Trochocystites, Barrande.

Size.—Length, parallel to the furrow, 5 to 8 mm.; width, 3 to 5 mm.

Type D, Plate XIV., Fig. *i*.

Ovate plates with pointed end. These have a distinct furrow along the axial line; they are convex all around, and have a short ridge inside near the apex.

Size.—Length, 6 mm.; width, 5 mm. Rare.

Type E, Plate XIV., Fig. *k*.

Triangular plate rather flat, having ridges diverging toward the rounded corners; ridges increasing in width and more prominent toward the outer ends. This plate may belong to a Cystidian.

Size.—Length and width, 5 mm. Rare.

Type F, Plate XIV., Figs. *l* and *m*.

Sub-triangular plates, rather flat, with curved margins, one concave and the other convex. An arched furrow, nearer one margin than the other, traverses them.—*Cirripodites cambrensis.*

Type G, Plate XIV., Fig. *n*.

Triangular plates of high relief, sometimes showing facets of contact on the sides next the pointed end. One side of the plate rounded.

Size.—Length, 4 to 5 mm.; width, 3 to 4 mm.

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Sculpture.—All these forms of plates, except for the keels and furrows described, have a comparatively smooth surface, there being only obscure lines of growth, and these not usually seen except toward the edges of the plates, and to these edges the lines are parallel.

Horizon and Locality.—Gray shales of Div. 1 *c* at St. John and Hanford Brook, St. Martin's. Somewhat rare.

The reference of these plates to Cirripedes is largely a matter of conjecture. As oval and circular plates have been found to occur along the dorsum of several genera of fossil Cirripedes plates of the type *L* and *D* may have had such a position, those of type *B* are evidently lateral, though the elongated form is unusual. Plates of the type *C* are more plentiful than the others and have the appearance of overlapping lateral plates. I have seen plates from the crown and lateral edges of a Trochocystites that resemble these, with similar flange and furrow. Plates of the type *F* more nearly resemble the opercular armature of modern Cirripedes, and seem to be the representatives in the old rocks of the conical plates of Plumulites,* and are perhaps scutal plates, while the type *G* is analagous to the laterals of such a genus as Scalpellum.† The longitudinal curved ridge of type *F* is comparable to those figured by Barrande. Hall and J. M. Clarke.‡

The broad sub-semicircular or subtrapezohedral form of many of these plates may seem unusual, but is not without a precedent in extinct genera, as Archæolepas and Loricula, which have rows of similar broad plates on the peduncle.§

In the shales which contain *Plumulites Manuelensis* at Manuel Brook, Newfoundland, are casts of calcareous plates which are similar to the above, thus resembling the coronal plates of Trochocystites; but they are different in form from those of the Eteminicus zone at St. John; the commonest form has a very heavy keel or furrow and is truncated at each end. The material is insufficient to determine the nature of these plates, which are sparsely scattered over layers in which *Microdiscus punctatus* abounds.

TRILOBITA.

Agnostus, Brongniart.

This is the most aberrant of all the primordeal trilobites of common occurrence, and the most difficult to associate with the

*Syst. Silur. Bohem., vol. i., Supp. pl. 20, figs. 7, 8 and 9 *b*. Pal. N. York, vol. vii., pl. xxxvi., figs. 1 and 3.

†Traité de Palæontologie, Zittel & Barrois, tome ii., p. 536.

‡Syst. Silur. Bohem. vol. i., Supp. pl. 20, figs. 22, 1 *a* and 5 *b*; also Pal. N. Y., vol. vii., pl. xxxvi., figs. 10, 11 and 16.

§ Traité de Palæontologie, Zittel and Barrois, p. 533 and 534.

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others by features held in common. The abortion of the posterior lobe of the glabella, the absence of the occipital ring, the immutable number of two joints in the thorax, all show the divergence from the common type; and also there is seldom seen on an Agnostus the proof of that development and expansion of the pygidium which can be traced in the moulding of the surface of this shield in most other primordeal trilobites.

Nevertheless there are some indications of a closer resemblance between Agnostus and its allies in the earlier stages of growth than appear in the adult trilobite. Owing to the minuteness of the shield in the young of this genera, it is difficult to make out the outline and contour of the test in the early stages; but it may be said that the pygidium is proportionately broader and both the marginal fold and furrow wider than is found to be the case at a later period; in the early larval stages it thus approximates more in form and contour to other trilobites than at a later period.

By comparing different species of Agnostus, and by a close examination of the surface features of the tests, we arrive at a few indications of the process by which this peculiar self-contained genus has been developed.

To look at some Agnosti (*e. g.* Regii*) one would hardly suspect that there are more than two lobes in the glabella, but on examining others (Fallaces and Longifrontes) it will be seen that there has been an abortion of the true posterior lobe (called "basal lobes"), so that in the Regii it has become a mere ridge. The so-called posterior lobe of the glabella is also itself in some species seen to be indented by two pairs of furrows; hence there are normally five lobes in the glabella.

The abortion of the true posterior lobes of the glabella (the "basal lobes") is the fixation of an early larval condition in Agnostus. This lobe in Agnostus never becomes an integral part of the glabella, but consists of two small triangular lobes (sometimes nearly obsolete) below the level of the glabella and connected behind it by a narrow thread-like ridge. The triangular form of these lobes is not embryonic, it shows a larval development up to a certain point; but its sub-ordination to the glabella and its separation from it, is evidence of subsequent arrest of growth.

The suppression of the occipital ring reduces the cephalic somites in Agnostus to five, which is the complete number in many trilobites which have this ring. In most species of Agnostus the occipital ring is not recognizable, hence the first

*The several sections into which the genus Agnostus has been divided by Tullberg are described at page 204.

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joint of the rachis has no protecting cover, except in so far as the attenuated posterior lobe (basal lobes) of the glabella may assume that office, an unusual condition with trilobites. *A. regulus* is the only species known to me that has an occipital ring.

Agnostus is the sole genus among the early Cambrian trilobites, except Microdiscus, in which the pleural groove runs forward in going outward toward the extremity of the pleura, and in association with this we find the point of the pleura in most Agnosti turned forward,* this is especially plain in Longifrontes. In Fallaces the pleural groove on the posterior segment lies along the front of the pleura, but on the anterior segment at the back; hence the pleura in this group is inflated in the middle and tubercle-like; on the anterior segment there are really two grooves, of which the anterior affords an interlocking edge with the marginal fold of the head shield when the body if folded together.

The long pygidium of an Agnostus assures us that this part has undergone very considerable changes from the early larval moults, but the proof is not often apparent; an examination of the tests of two species (*A. Acadicus* var. *declivis* and *A. Nathorsti*) give an inkling of the way in which the changes have ome about—those which resulted in the three-lobed rachis of the early Agnosti.

In *A. Nathorsti* and other Lonigifrontes the attenuated and depressed end of the rachis is the original pygidium, the front of this part is marked by a minute tubercle (to be found only in well preserved tests); in a rare example of the pygidium of *declivis* three pairs of scars behind this tubercle point out the existence of three somites here; two pairs of scars in front of this little tubercle indicate the presence of two more somites, which complete the posterior lobe of the rachis; these two somites swell out to greater width and height than those behind; the anterior of these two somites is also sometimes further marked off by a pair of furrows, one on each side of the rachis corresponding to the oblique furrow on each side of the anterior lobe of the adult rachis; in Regii these furrows are so strongly developed that this somite was counted by Barrande as a part of the middle lobe of the rachis. The middle lobe and the anterior lobe of the rachis form another enlarged pair of somites with a tubercle or spine at the back, and correspond to the two front somites of the posterior lobe.

We thus see that by its pygidium Agnostus shows three stages

*An exception to this almost universal rule is *A. granulatus* Barr., but it is one of the few Agnosti that have genal spines.

NOTE—204 of last line p. 208, should be 210.
TRANSACTIONS N. Y. ACAD. SCI., XV., Sig. 11, August 14, 1896.

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of development: 1. The early larval stage—non-agnostiform—when it possessed about 1–3 somites; 2. The later larval stage—agnostiform—when it had about 4–5 somites; 3. The adult condition, when it had about 6–7 somites, and the three main lobes of the rachis were developed with 4–5 somites in the posterior of the three.

The above remarks are based wholly upon the three types of Agnosti that appeared in Europe and America simultaneously in the first sub-fauna of Paradoxides. To us the special features of the other two sections of the genus are of less moment, as they appear to be simply a progressive effacement of those that are found in the earlier types; and it is in accordance with this that they appeared later in time, the Parvifrontes in the third sub-fauna of Paradoxides, the Lævigati scarcely before the fourth, while these latter culminated in the sixth, seeing that the beds are called the zone of *Agnostus lævigatus*.

In these later types of the Paradoxides beds both the glabella and the rachis are effaced, so that scarcely any means remain of distinguishing the heads from the tails in these smooth tests. Nevertheless it is not such aberrant types that carry on the genus Agnostus to a later time, but modifications, more direct, of the primitive types; for though the Regii disappeared from the stage of life in the early Cambrian time, Fallaces and Longifrontes survived in the Ordovician seas, and the former lived on to its close. Thus this type which was the most abundant when the Agnosti appeared in the seas of Sweden, Wales and eastern Canada was the last to disappear when the genus was finally extinguished at the close of Ordovician time.

Tullberg, in his classical memoir on the genus Agnostus,* divides it into four groups, distinguished by well marked and easily recognized characters.† The arrangement is such as to greatly aid in determining the species of this large genus, so characteristic of all parts of the Cambrian from the Olenellus zone upward. The greatest development of the genus is in the Paradoxides zone, and especially the upper part.

The following are Tullberg's sections:

Longifrontes. "Distinguished by a manifest extension of the glabella and rachis, which commonly is rather long. Test sometimes smooth, sometimes the cheeks are furrowed, sometimes the test both on the cheeks and pygidium is studded with elevated points. The marginal fold is generally narrow. The cheeks in

*Om Agnostus arterna i de Cambriska aflagringarne vid Andrarum. S. A. Tullberg, Stockholm, 1880.

†It may also with propriety be divided into five sections as the Limbati contains two very distinct types.

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front of the glabella and the side-lobes behind the rachis of the pygidium are divided by an indented line."*

This group, both in Sweden and eastern Canada, was one of the first to appear, and it proved also to be one of the most persistent. The following species and varieties may be referred to it:

Agnostus obtusilobus.
A —— Davidis, Hicks.
A —— gibbus, Linrs.
A —— —— var. partitus.
A —— —— var. acutilobus.
A —— Nathorsti, Brögg. and var. confluens, n. var.
A —— fissus, Lundg., and var. trifissus, n. var.
A —— punctuosus, Ang.

Limbati. Tullberg divides this group into two sections, viz., Regii, of which *A. rex*, Barr, is the type, and Fallaces, with *P. fallax*, Linrs., as the type. Both sections are old, being found in the earliest Paradoxides beds both in Europe and America. This group (Limbati) has the following characters: "A shield which is generally more quadrate in form than the Longifrontes; the head shield has a broader marginal fold; the basal lobes of the glabella are more prominent; the cheeks in front of the glabella are not separated by a furrow, and they are smooth, and the pygidium commonly has a pair of spines at the back margin."

"The section *Regii* is distinguished by its broad marginal fold, by the reduced cheeks and reduced side lobes of the pygidium; also the glabella, especially at the front part, is broad, and the third joint of the rachis of the pygidium is shortened."

The Regii have been found in America in the first and third sub-faunas of the Paradoxides zone. Only two species are known.

Agnostus regulus, and
A ——— Rex, Barr., var. transectus n. var.

The section *Fallaces* has the following characters: "The head shield is smaller, the marginal fold not so broad, the cheeks are larger, the basal lobes of the glabella rather large, and the third joint of the rachis of the pygidium is the largest."

The following species are found in eastern Canada and Newfoundland:

Agnostus fallax, Linrs., var. vir.
A ——— —— var. concinnus.
A ——— —— var. trilobatus n. var.
A ——— Acadicus, Hartt.
A ——— —— var. declivis.

* The last character is not constant as regards the pygidium.—G. F. M.

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Parvifrontes. "This group is distinguished by the incomplete development of the glabella, which is not divided into lobes."

In eastern America this group appears first with the Abenacus sub-fauna, and has the following species:

Agnostus parvifrons.
A ——— ——— var. tessella.
A ——— ——— var. truncatus.
A ——— umbo.

Lævigati. "This group is distinguished by the more or less complete effacement of the glabella and the rachis of the pygidium.* The test is always smooth and shining, sometimes with traces of furrows. The marginal fold has a tendency to disappear from the head shield, but becomes broad on the pygidium."

The group has been found in the Paradoxides beds of America, chiefly in those of Newfoundland. It comes in freely with the Davidis sub-fauna.

The following species occur:

Agnostus lavigatus, Dalm., var. terranovicus n. var.
A —— —— var. ciceroides n. var.
A —— —— var. mammilla n. var.
? A —— nudus Beyr.

In describing the following species the author has not followed Tullberg's arrangement entirely, because he has found Longifrontes rare in the first sub-fauna, their great development was in the third, fourth and fifth sub-faunas. On the other hand, the Regii appear to have been verging towards extinction, as in America they disappear with the advent of the Abenacus (third) sub-fauna. The arrangement adopted is Regii, Fallaces, Brevifrontes, Longifrontes, Lævigati.

The Agnosti of the American Paradoxides beds have a definite order of succession, corresponding nearly to that observed in those of Europe, viz.:

In the P. lamellutus sub-zone are the following: *Regii.* A. regulus—*Fallaces.* A. fallax, and var. vir., and var. trilobatus—*Longifrontes.* A. gibbus and var. partitus.

In the P. Eteminicus sub-zone.—*Fallaces.* A. fallax and A. Acadicus.

In the P. Abenacus sub-zone.—*Regii.* A. rex var. transectus —*Fallaces.* A fallax var. concinnus. A. Acadicus var. declivis—*Parvifrontes.* A. parvifrons and var. tessella and var. truncatus and A. umbo—*Longifrontes.* A. obtusilobus. A. gibbus var. acutilobus, A. Nathorsti and var. confluens, A. fissus and var. 3-fissus.

*This last (the effacement of the rachis) is not a constant feature.

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In the P. Davidis sub-zone.—*Fallaces* A. Acadicus var. declivus—*Parvifrontes.* A. parvifrons—*Longifrontes.* A. Davidis, A. fissus, var. trifissus, A. punctuosus—*Lævigati.* A. lævigatus var terranovicus, var. ciceroides and var. mammilla, A. nudus.

AGNOSTUS REGULUS. (Plate XVI., figs. 1*a*, *b* and *c*.)

Agnostus regulus. Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 67, pl. vii., figs. 1 *a–c*.

Amended Description.—Body elongate-elliptical, with straight sides and semi-circular ends.

Cephalic shield elongate, semi-elliptical: posterior contour broken by the projecting glabella and narrow occipital ring. Width and length of the head shield nearly equal. Dorsal furrow distinctly but not deeply impressed. Marginal furrow and fold are sharply defined, and the latter diminishes toward the posterior angles of the shield.

Glabella large, consisting of two lobes; the anterior semicircular, wider than the posterior lobe, elevated above the general contour of the surface, and in some examples undulate with broad furrows, spreading from the back of the lobe; posterior lobe flattened-cylindrical, with a broad, faint transverse furrow, one-third from the front, interrupted at the summit of the glabella by a small tubercle, elongated on the line of the axis. Basal lobes obsolete, being merged in the posterior marginal fold. Occipital ring minute, narrowly lenticular, concealed below the projecting obtusely angular end of the glabella. The cheeks are narrowed in the middle, there being a crescent-shaped limb in front of the anterior lobe of the glabella, and a broad rectangular limb on each side of the posterior lobe of the glabella.

The thorax consists of two segments; the anterior subarcuate and marked by five lobes that are bounded by furrows radiating backward; the inner pair of lobes are larger than the outer. The posterior segment of the thorax is unknown.

The pygidium is elliptical, with straight sides, and is truncated in front of the side lobes; it is widest at the anterior angles. The rachis is large, high, obtusely clavate, constricted in the middle, and divided into three lobes; the anterior lobe is narrow, especially in the middle; the middle lobe is short and sublenticular in form and bears an elongated ridge like tubercle on the apial line that projects backward across the anterior segment of the third lobe; the third lobe is subpentagonal in form and has a pair of side furrows in the widest part. The lateral lobes of the pygidium are narrowed opposite the posterior part of the rachis and meet behind it.

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Size.—Length, 6 mm.; width, 2½ mm.

Horizon and Locality.—Found in the fine gray shales of Div. 1 c^1 at St. John and at Porter's and Hanford Brook, St. Martin's, N. B., but nowhere plentiful.

This little species is remarkable for the large size of the glabella and the rachis; in these features and in the expanded anterior end of the glabella it resembles *A. rex*, Barr. and *A. regius*, Sjogr., but there are no raised lobes on the cheeks similar to those species, and the proportions of the glabella, etc., differ. It is nearest the latter species.

AGNOSTUS REX, Barr. var. TRANSECTUS n. var. pl., xvi., fig. 2.

This form differs from the type as described and figured by Tullberg in having the first and second segment divided completely; for there is no continuous ridge on the rachis from the front to the middle of the shield, as in the type; but the ridge arises toward the back of the middle lobe, and thence stretches nearly across the anterior segment of the posterior lobe.

It also differs from the type in the proportionately longer rachis, and in the narrowness of the raised area which encloses the end of the rachis; here the rachis almost touches the flattened band which runs around the shield within the margin.

Size.—Length of pygidium, 6¼ mm; width, 6 mm.

Horizon and locality.—Dark gray shales of Div. 1 d^1, at Porter's Brook, St. Martin's. Rare.

AGNOSTUS FALLAX, Linrs. pl. xv., figs. 8*a* and *b*.

Agnostus fallax Linrs. Om Vestergot. Cambr. och Silur-aflagr., p. 81, tab. ii., figs. 54, 55.

Agnostus fallax, Brögger, Om. Paradoxid. skifr. ved. Krekling, Nyt. Mag., Christiania, 1878, p. 64, tab. vi., fig. 1, 1 *a*.

Agnostus fallax, Linrs. Om. faun. i lagr. med Paradox. Œland. Geolog. förenin, Stockholm, 1877, p. 371, pl. 15, fig. 7.

Agnostus fallax, Tullb. Om Agnostus arterna, p. 31, pl. ii., fig. 22.

The following is Linnarsson's description of this species:

"Test smooth. Head-shield subquadrate, surrounded by a wide margin glabella bilobed, anterior lobe broad, posterior lobe with an indentation on each side in front of the middle, furnished with an elevated point behind the middle. Basal lobes large triangular. Cheeks confluent in front of the glabella. Pygidium subquadrate, surrounded by a marginal fold which is broader behind and bidentate. Rachis scarcely three-jointed, the first joint with obsolete lateral tubercles, middle joint ornamented with an elevated point."

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The *typical* form is described as "Rachis of the pygidium long, nearly reaching the margin, lateral lobes greatly narrowed behind, scarcely meeting behind the rachis, marginal fold moderately broad."

Size.—Length and breadth of the shield, 3-4 mm.

There is so much difference in the tests which are referred to *A. fallax* by Swedish geologists that I am constrained to admit that the form I have described as *A. vir* can be included as a variety under it, and it is here so described; it is in fact nearer the typical form than *A. fallax*, var. *ferox*, Tullb.

Development of the young.—Several small heads and tails of the following variety of this species show important differences from the adult. The head when of the length of ½ mm. shows a narrow, cylindrical glabella, divided into four lobes by furrows indenting the sides; the first furrow crosses, but is shallow in the middle, the second is less distinct, the third is fainter still; the basal lobes cannot be seen. When the head has grown to the length of 1 mm. the anterior furrow alone is distinct, and the glabella is much as in the adult.

The pygidium in the larva of this size (1 mm. long) is proportionately shorter and the rachis more prominent than in the adult, and the marginal fold and cusps are quite distinct; three transverse undulations divide the rachis into four somites; these divisions except remnants of the anterior one disappear in the adult, as does also a minute spine at the back of the third lobe from the front. The embryonic pygidium is indicated by the low and weak part of the rachis behind the small spine visible on this tailpiece.

An example 1¼ mm. long of the pygidium of this variety bears four cusps at the posterior border, but this extra armament is rare; it may be compared with var *tricuspis* found by Brögger in the Paradoxides bed of Krekling, in Norway,* which has a central cusp between the two usually found.

Agnostus similis Hartt, which Walcott makes a synonym of *A. Acadicus* might belong here but for its want of spines on the caudal shield.

Var. VIR. pl. xv., fig. 6.

Agnostus vir. Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 69, pl. viii. fig. 3.

? *Agnostus similis*, Hartt, Acad. Geol., 2d ed., p. 606.

This is a larger form than the type, and differs in the more conical glabella, with the spine set further forward, in the com-

*On Paradoxidesskifrene ved Krekling, p. 87, Tab. vi., fig. 1a.

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paratively smooth ring of the posterior joint of the thorax, and in the absence of segmentation in the rachis of the pygidium.

Size.—Length, 12 mm; width, 5 mm.

Horizon and locality.—This variety has been found only at St. John in Div. 1 c^1. The typical *fallax* occurred here also, but is more common at Hanford Brook in Div. 1 c^2.

Var. CONCINNUS. pl. xv., figs. 7*a* to *c*.

Agnostus vir. var. *concinnus*, Trans. Roy. Soc. Can. vol. iii., pt. iv., p. 70, pl. vii., figs. 4*a* to *c*.

This form presents the following differences from var. *vir.*: The glabella is more cylindrical, is proportionately longer and the cross-furrow is directly transverse. In the thorax the last segment carries five distinct lobes, the middle lobes being segmented. In the pygidium at the anterior end of the rachis, a small triangular lobe is faintly defined on each side. This variety is smaller than in the type.

Size.—Length, about 9 mm; width, 3½ mm.; cephalic shield, 4 x 3½ mm.

Horizon and Locality.—The fine dark gray shales of Div 1 d^1 at Porter's Brook, St. Martin's, etc.

Development of the Young.—Both the head shield and pygidium of the ½ mm. size have been found in this form. The front furrow of the glabella is more distinct than in the preceding variety, and the basal lobes are scarcely visible. At 1¼ mm. some heads develop a short furrow from each front corner of the glabella, running forward; this furrow is sometimes seen in the adult of *A. fissus*. A head shield 3½ mm. has three furrows of this kind; one median.

The pygidium of ½ mm. size already has the marginal fold and furrow distinct, but the furrow is not widened backward, though the fold is and is cuspidate. The rachis is prominent, except behind, and the front lobe is marked off by a shallow furrow; the width of the second lobe is defined by the long axial tubercle; behind it is a third lobe, not defined by any furrow, weak and at the end sinking below the level of the cheeks, which meet and are wide behind it. In this small pygidium there is no fourth lobe in the rachis, but this is developed in the 1¼ mm. shield, which differs little from that of var. *vir* of the same size, except that the posterior tubercle has not been observed.

Var. TRILOBATUS. pl. xv., fig. 9.

Agnostus partitus (supposed pygidium). Trans. Roy. Soc. Can. vol. iii., p. 68, pl. vii, fig. 2*b*.

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A head shield associated with this pygidium does not differ from the type of *A. fallax*, but the pygidium does.

Pygidium quadrate, somewhat wider than long, marginal fold and furrow sharply defined in front, wide at the sides and with strong spines. Rachis trilobed by two strong transverse furrows, which are deeply cut in the middle and also at the extremities with a shallower space between; the anterior lobe is narrow with lateral tubercles, middle lobe crossed by a strong keel-like tubercle, posterior lobe having a somite about as wide as the middle lobe, marked off at the front by a shallow furrow, not always distinguishable.

Size.—Length of the caudal shield, about 3 mm.

Horizon and Locality.—Fine grey shales of Div. 1 *c*.[1]. St. John. Scarce.

This pygidium is of considerable interest because it represents in the adult condition a larval phase of Agnostus. It is instructive to compare it with the 1 mm. larval form of *A. fallax* (type) (pl. xv., fig. 8*b*) which shows a similarly, but more imperfectly segmented rachis. This pygidium is the only one of the Fallax section which is distinctly segmented; it thus expresses a condition of that shield quite common in the Longifrontes, and partly for that reason was at first thought to be the caudal shield of *A. partitus*; the general facies however, is that of a Fallax.

AGNOSTUS ACADICUS Hartt. pl. xv., figs. 10*a* and *b*.

Agnostus Acadicus Hartt. Acad. Geol. 2d ed. p. 665, fig. 229, U. S. Geol. Surv. Bull. 10 p. 22, pl. ii., figs. 2*a*, *b* and *c*. Trans. Roy. Soc. Can. vol. iii., p. 70, pl. vii , figs. 5*a* and *b*.

Head minute, transversely elliptical, or subcircular, breadth and length about equal, convex but very depressed, outlines in front and on the sides slightly straightened. A narrow, flattened and but very slightly elevated border goes round the front and lateral margins. This is separated from the rest of the shield by a narrow, shallow, flat space, or groove, which on going posteriorly along the lateral margins loses gradually in width towards the posterior angles of the shield, which are rounded. Glabella a little less than two-thirds of the length of the shield, long elliptical, depressed convex, but more elevated than other parts of the shield, about twice as long as broad, bounded anteriorly and laterally by a sharp but rather deep groove concentric to the outer one above described. A well marked transverse furrow arching backward separates the anterior third of the glabella as a subcircular lobe. Posterior part of the glabella rounded, but impressed on each side by a little

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lobe situated in the angle between the cheek lobe and the glabella. These little lobes [basal lobes] are about one-quarter of the size of the anterior glabellar lobe; cheeks of the same width throughout, and uniting in front of the glabella, being bounded by the two concentric grooves above mentioned. Posteriorly they are rounded; in width they are rather greater than the glabella. They are convex, more elevated along their inner margin, but sloping outward roundly and evenly. Glabella with its lobes project considerably beyond the posterior margin. Surface smooth.

"Pygidium of this species (?) of about the same outline as the cephalic shield. The posterior and lateral margins have a slight, raised border, separated from the lateral lobes by a shallow but well marked groove, running parallel to the margin. This groove widens at the point where it bends to go forward along the sides in such a way as to encroach on and thin out the marginal fold, and just before reaching the anterior margin it narrows itself from the inner side, so as to cause the lateral lobes to widen somewhat anteriorly. These are narrow, flattened, about half as wide as the middle lobe, narrowing to a point just behind the middle lobe, where they do not unite. The medial lobe is about five-sixths of the length of the pygidium, shield-shaped, flattened, convex, more elevated than the lateral lobe. Its anterior border is slightly concave in the middle. The lateral angles are rounded, and the lobe is contracted a little anteriorly. It is bounded by two deep and well marked furrows, which join one another in the middle of the marginal furrow, forming a pointed arch; median lobe projecting farther forward than the lateral ones. A little spine is situated on its mesial line; about one-fourth of its length from its front, surface smooth."

Mr. Walcott remarks: "After a careful study of all the specimens in the collection, fifteen in number (Hartt's collection at Cornell University), I am unable to make out sufficient difference between the form described as *A. Acadius* and that given as *A. similis*, to establish two species. There is a certain range of variation in the specimens, as pointed out by Mr. Hartt, but that is so variable and owes its origin so largely to the conditions of preservation of the various specimens that it is not evident that the two species are typified."

After examining much larger collections of the Agnosti of Div. 1 *c* (the horizon of the St. John group from which Prof. Hartt's collections came), than Walcott had under review, I am not altogether satisfied with the the above determination, though it appears to be the best solution as to the use of Hartt's names.

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It appears strange that while *A. fallax* and its varieties are by far the most common Agnosti of that horizon, Hartt should describe only spineless pygidia; these I find comparatively rare at this horizon, though they become plentiful in Div. 1 *d* (whose fauna Hartt did not have). And then the description of *A. similis* more nearly accords with that of *A. fallax* than does that of *A. Acadicus*.

Size.—Length of each shield, 5 mm.; width, 5½ mm.

Horizon and Locality.—Grey shales of Div. 1 *c* at St. John, Radcliff's stream, etc.

Var. DECLIVIS. pl. xv., figs. 11*a* to *d*.

Agnostus Acadicus var. *declivis*, Trans. Roy. Soc., Can. vol. iii., p. 70, pl. viii., figs 6*a* and *b*.

This form is closely allied to *A. Acadicus*, but presents the following differences: It has a narrower border fold and smaller basal lobes, the glabella has proportionately a longer anterior lobe, and the furrow dividing it from the posterior lobe is directly transverse; the posterior lobe is strongly elevated, almost tumid behind, and bears a small round tubercle at the middle of its length; in front of the tubercle the lobe slopes down rapidly to the cross-furrow.

Differences of equal import are found to exist between the pygidia of the two forms. In var. *declivis* the rachis is cylindro-conical, and there are three minute lobes on each margin near the anterior end; in *A. Acadicus* the rachis is more triangular in form, and both the head and tail shields are found of a larger size than those of the variety. The marginal fold is not quite even, but is interrupted not quite half-way to the back of the shield by a small, inconspicuous, knob-like spine. A pair of furrows just in front of the tubercle on the glabella, and snother pair a little behind it, both directed slightly backward, slightly indent the sides of the glabella.

The thorax, of two joints, has three lobes on the axis of each joint, the mid-lobe being wider, and the side lobes lower on the posterior than on the anterior joint; the pleura have furrows directed forward; that on the hinder joint is placed on the front and that on the interior joint on the back of the pleura.

This variety has the head of a Fallax with the tail of a Brevifrons (*e. g.*, *A. parvifrons* Linrs.).

Development of the young.—Head shield of ¾ mm. long has no visible basal lobes, but otherwise does not differ much from the adult. In a head 1¼ mm. long these lobes become visible, but are very narrow and are confluent with the posterior marginal fold.

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The pygidium is more remarkable. One of ¾ mm. has an oval form; the anterior margin is straight and without fold, marginal fold around the rest of the shield widening backward. Rachis oblanceolate, trilobed by faintly impressed furrows, front lobe narrow, middle lobe wide but not tuberculate, side lobes with two transverse furrows, the posterior about one-third from the front.

In this individual I conjecture that the anterior of the two furrows on the side lobes, will become the anterior marginal furrow of the pygidium, and the posterior a first furrow on the side lobe; the pygidium would then agree with a similar stage of Microdiscus as regards these lobes, but not as regards the rachis.

This minute pygidium shows a simpler structure than the adult, which, notwithstanding that the rachis is not segmented, is sometimes so preserved as to show the number of somites in the rachis. Thus the adult caudal shield (see pl. xv., fig. 11*d*) is sometimes well enough preserved to show on the cast of the inner surface a row of minute tubercles on each side of the rachis (five in number) and two on the axial line; the lateral tubercles are placed on the line between the somites, and each of the axial tubercles in the middle of a somite; it thus appears that the somites are in pairs, one with and the other without an axial tubercle. The first and second somites correspond to the first and second lobes of a Longifront pygidium, and the remainder of the axis to the third lobe in the pygidium of an individual of that section of Agnostus. Also we observe that while in the first larval stage there are only three somites recognizable in the pygidium, the adult caudal shield has six.

Agnostus declivis may be compared with the later *A. secretus* Walc., of the Prospect Mountain group, which it resembles in general form as well as in having the glabella tumid behind. Neither this variety nor the type of *A. Acadicus* appears to have any very near allies among the species of the Paradoxides beds of Sweden, known to the author.

Size—Length, about 7 mm. Width, 3 mm. Cephalic shield 8 x 3 mm.

Horizon and Locality.—Abundant in the fine, dark shales of Div. 1 d^1 at Porter's Brook, St. Martin's.

AGNOSTUS PARVIFRONS Linnarsson.

Agnostus parvifrons Linrs. Om. Vestergötland Cambr. o. Silur. aflagr., p. 82, tafl. 2, fig. 56, 57.

Agnostus parvifrons Tullb. Om. Agnostus-arterna, p. 34, tafl. ii., figs. 26, 27, 28.

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Test smooth. Head-shield enclosed by a marginal fold that is broader in front. Glabella small, round, not lobed. Basal lobes small. Cheeks expanded, connected in front of the glabella; pygidium without spines; marginal fold wider behind; rachis long, almost reaching the border; lobes sometimes obsolete, sometimes apparent; middle joint ornamented with an elevated point; lateral lobes narrowed behind, scarcely contiguous.

Size.—Length and breadth of each shield, $3\frac{1}{2}$–$4\frac{1}{2}$ mm.

Horizon and Locality.—Dark gray shales of Div. 1 d^1 at Porter's Brook, St. Martin's, etc.

Mr. C. D. Walcott has described a species of *Agnostus* of the *parvifrons* type found in the Lower Cambrian rocks of Washington County, N. Y. Being claimed as a Lower Cambrian (*i. e.*, Olenellus Zone) fossil, it is not figured here. The glabella is longer than in *A. parvifrons*. It may be remarked, however, that this type of *Agnostus* is not found elsewhere lower down than the *P. Abenacus* (=*tessini*) sub-zone.

A common variety in Canada is the following:

Var TESSELLA. pl. xvi., figs. *a* to *c*.

Agnostus tessella. Trans. Roy. Soc. Can. vol. iii., pt. iv., p. 71, pl. vii., figs. 7*a* to *c*.

This is a transitional form to the Limbati (Fallaces). It differs from the type in having an anterior lobe to the glabella faintly defined; this has no furrow like the posterior lobe, but is marked out by a faint thread-like line on the surface of the test. The posterior lobe is intermediate in length between the two glabellas of *A. parvifrons* figured by Tullberg, but rectangular in front. The pygidium is similar to fig. 27*b* of Tullberg's plate, but the tubercle is elongated, not round as in that form; the rachis is wider, and its middle lobe proportionately shorter. The marginal fold does not have so great a width behind.

Size.—Length and width of the shields each 3 mm.

Horizon and Locality.—Same as the preceding.

Development of the Young.—A head shield $\frac{1}{2}$ mm. long is narrow, marginal fold and furrow distinct. Glabella long, front furrow distinct, two others faintly marked by depressions crossing the glabella; basal lobes very narrow, scarcely visible.*

A head $1\frac{1}{4}$ mm. has nearly the form of the adult, slight furrows at the anterior corners of the glabella as in *A. fissus* var.

* This is in accordance with the changes of this lobe in the Ptychoparidæ in which during the first larval satges this somite is very narrow and weak.

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trifissus. A head 3½ mm. shows three fore-furrows of the glabella as *A. trifissus*, but no axial furrow of the glabella.

A pygidium ½ mm. long, is wide, subquadrate, marginal furrow distinct, not widened; fold widened, cuspidate, rachis prominent, front lobe divided off by a shallow furrow, second lobe defined only by the axial tubercle, third lobe not defined, weak, rapidly descending below the cheek lobes, which are wide behind the rachis. A pygidium 1¼ mm. long, is quadrate; the third lobe from the front is defined, but the little tubercle is absent. Another common variety is the following:

Var. TRUNCATUS n. var.?

? *Agnostus truncatus* Brögg. Om. Paradoxides skifrene ved Krekling, p. 72, tab. vi., fig. 8.

Brögger's figure, except that it is somewhat more quadrate and larger, is not distinguishable from a common variety of *A. parvifrons* that occurs in the St. John group. The variety found here does not differ from var. *tessella*, except that the front lobe of the glabella is entirely suppressed, and that the individuals are found of larger size.

Size.—Length and width of each shield, 4 mm.

Horizon and Locality.—As the preceding.

Considering these varying forms, we are impressed with the justice of Tullberg's remark that this is a variable species. In *Agnostus Acadicus* of Hartt we may perhaps have an ancestral form of this species; that occurs in the sub-zone of Paradoxides Eteminicus; then in the sub-zone of P. Abenacus we find three other forms, var. *declivis* of *A. Acadicus*, in which the front lobe begins to be depressed, var. *tessella* of *A. parvifrons*, in which the front lobe is traced out on the surface of the head-shield only by an impressed line, and not by furrows, and var. *truncatus*, in which the front lobe entirely disappears; finally, one may add the typical form of *A. parvifrons*, in which any suggestion of an anterior lobe is removed by the rounding of the front of the glabella. It will be noted that there is a resemblance in the pygidia of all these forms, and that *A. Acadicus* differs from the typical Fallaces in the absence of marginal spines to the pygidium, a feature which it possesses in common with all *parvifrontes*.

AGNOSTUS UMBO, pl. xvi., figs. 4*a* and *b*.

Agnostus umbo. Trans. Roy. Soc. Can. vol. iii., pt. iv., p. 71, pl. vii., figs. 8*a* and *b*.

Body elliptical, broader in front than behind, high at the inner side of the head and tail shields, descending thence to the front

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and back. Cephalic shield broadly-transversely elliptical, high and contracted behind, sloping from the glabella in all directions. Marginal fold and furrow strongly marked. Dorsal furrow deep. Glabella suborbicular, rounded in front and behind, bearing a small tubercle on the axial line, one-third from the front; the width of the glabella is more than a third of that of the shield, and its length nearly half. The thorax is unknown. The pygidium is semi-elliptical, with rounded anterior corners; the width is nearly a quarter greater than the length. Both dorsal and marginal furrows are deeply impressed. The rachis is conical and is greatly elevated above the rest of the shield; it is slightly constricted near the anterior end, and about one-third from the front bears a small tubercle. The lateral lobes of the pygidium are rounded in at the anterior end by the rapid curve of the marginal furrow; and at the posterior end are gradually narrowed and are separated at that end by a furrow which connects the dorsal and marginal furrows. The marginal fold is rather wide at the extremity of the pygidium, and is rounded at the anterior corners.

This species is distinguished from *A. tessella* by the entire absence of the anterior lobe of the glabella, and by the round and prominent posterior lobe, having a small tubercle in advance of the middle of the lobe. The pygidium has a shorter, higher and more conical rachis, and the tubercle on it is round, not elongated as in *A. tessella.*

The head shield of *A. parvifrons* var. *mammillata* Brögg resembles that of this species, but is longer; the rachis also of the pygidium is more cylindrical and its tubercle further back in Bröggers' variety.

Size.—Length, 6 mm.? width, 3 mm.

Horizon and Locality.—In the fine dark shales of Div. 1 d^1, Porter's Brook, St. Martin's. First collected by Dr. L. W. Bailey.

The following species are classed as *Longifrontes*, although, from the absence of axial furrows, the one which is here first described might seem to be not properly placed there; but the thin, flexible test, the large basal lobes and the attenuated and segmented rachis seem to point to this as the proper place for *Agnostus obtusilobus*, the largest species found in the St. John group.

AGNOSTUS OBTUSILOBUS, pl. xvi., fig. 5.

Agnostus obtusilobus. Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 72, pl. vii., fig. 9.

Amended Description.—Body elliptical oblong. Cephalic

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shield semi-elliptical, about one-quarter wider than long. Dorsal furrow faintly impressed. Marginal fold and furrow strongly marked. Glabella elliptical-elongate, wider behind, rounded in front, in its widest part nearly a third of the width of the shield; narrowed at the base by two triangular lobes; a semi-elliptical lobe at the anterior end more than one-third of the length of the glabella. Occipital ring and posterior marginal fold narrow. Cheeks continuous in front of the glabella. Thorax of two segments; the anterior segment has five lobes, of which the outer pair are globose and the inner pair subtriangular and widest in front; the center lobe is semi-circular, broad behind, and bears an elongate traverse tubercle in the middle. The posterior segment has three lobes, of which each of the two lateral ones is globose, and bears minute tubercles; the central lobe is subrectangular elongate, and the middle half is traversed by an arched furrow, which begins and terminates on the posterior margin of the segment. The pygidium is semi-elliptical, about one-sixth wider than long, and has the anterior margin arched forward. The marginal fold and furrow are about as distinct as those of the head shield. The rachis is oblanceolate, constricted in the middle, clavate, and pointed behind, about one-third longer than wide; it is traversed by two furrows, of which the one near the anterior end arches forward, and the other, near the middle of the rachis, arches backward. At the broadest part of the axial lobe there is transverse depression. The first segment of the rachis is narrow and elevated transversely; the second segment is elevated lengthwise, having an elongated tubercle at the axial line that projects backward on the third segment; the third segment is triangular and depressed across the middle, and bears a small axial tubercle on the anterior third.

Sculpture.—The surface of the test in this species has a velvety appearance, and under the lens is seen to be covered with minute granulations, the surface also is rugulose or uneven, and the test thin and more apt to be distorted than those of the two preceding species. The parts of the body in this and the following Longifrontes are more frequently found connected than are those of the preceding species; and while in the species above described the two shields are often found doubled together, in this and the following species they are frequently spread at length. This species resembles *A. scarabeoides* of the Welsh Cambrian rocks, but has a narrower glabella with a more obtuse front.

Length, 11 mm. Width, 6 mm.

Horizon and Locality.—In the fine dark grey shales of Div. 1 d^1, at Porter's Brook, St. Martin's. Infrequent.

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The pygidium of this species may be distinguished from that of *A. acutilobus* in the fact that the tubercle of the second joint encroaches so decidedly on the third joint as to make a strong sinus in the dividing furrow; also it may be distinguished by the proportionately shorter third joint of the pygidium. This species appears to have no lateral spines to the pygidium.

AGNOSTUS DAVIDIS, Hicks. Plate xvi., fig. 6.

Agnostus Davidis, Hicks. Undescribed fossils of the Menevian group. Jour. Geol. Soc. London, 1872, p. 173, pl. v., figs. 2 to 4.

A large pygidium, about the size of that of Hicks' species above named, occurs at Manuel Brook. It is flattened in the shale and so its contour is not known. Dr. Hicks' examples appear to have been distorted by pressure; allowing for this our example agrees fairly well with the pygidia he figures; his description of the species is as follows:

"Head rounded and forming about two-thirds of a circle, and about $\frac{3}{8}$ of an inch long, surrounded by a narrow border. The glabella occupies about one-third of the width, and tapers forward. It is divided at the base of the anterior third, by a transverse furrow, into an anterior spheroidal lobe and a posterior-elongated lobe, the anterior part of which is raised centrally; there is a triangular lobe on either side at the base of the glabella. Cheeks slightly raised and gibbous.

Thorax depressed, strongly trilobed; pleuræ grooved deeply to the tips. Axis trilobed, the central lobe being largest and pyramidal in shape. The two lateral lobes triangular in shape.

Tail of the same shape as the head, but more strongly margined. The axis is large and occupies more than a third of the width, reaches backwards to within a short space of the posterior margin and is indented by three furrows on each side, each running obliquely backwards from the centre, which is somewhat raised.

This is the largest species found in the Menevian group. Found at St. David's and near Dolgelly, North Wales."

In the American examples I cannot recognize the third furrow of the axis of the pygidium mentioned and figured by Dr. Hicks, and on the other hand he does not describe a low tubercle which is found on the second lobe of the pygidium in this American form.

Sculpture. The axis and side lobes are covered with minute

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tubercles, only visible with a lens. Size of this caudal shield, length and breadth each 9 mm.

Horizon and Locality. Grey shales of the *P. Davidis* Zone at Manuel Brook, Conception Bay, Newfoundland.

This species is distinguished from *A. scarabeoides*, Hicks, by the absence of visible tubercles on the surface of the test.

AGNOSTUS GIBBUS, Linnarsson.

Agnostus gibbus, Linrs. Om Vestergot. Cambr. Silur. Afiagr. p. 81, tab. ii., figs. 52, 53.

Agnostus gibbus, Broegg. Om Paradox, lagr. v. Krekling, tab. vi., fig. 11.

Agnostus gibbus, Linrs. Om faun. i Kalk. m. Conocoryphe exsulens, p. 22, tafl. ii. figs. 31, 32.

Agnostus gibbus, Tullb. Om Agnostus-arterna, p. 15, tafl. i., fig. 2, *a* and *b*.

The following is the diagnosis of this species: "Test smooth. Head surrounded by a narrow subfiliform border. Glabella 2-lobed, anterior lobe rounded-subtriangular, equalling the posterior lobe in width, posterior lobe elevated into a tubercle, often very tumid, in the anterior part of which tubercle an elevated point can sometimes be seen. Basal lobes small, entire, rounded triangular, connecting behind the above tubercle by a narrow rim. Cheeks without lateral grooves, separated in front of the glabella by an impressed line. Pygidium rounded, without spines, and having a narrow border fold. Rachis 3-jointed, the anterior joint divided into three parts by two longitudinal depressions, of which the middle is the smallest; the middle joint narrower than the others, but much higher, produced backward into a rather long, free denticle which almost always is broken off; the posterior lobe large, convex, rounded-acuminate behind. Lateral lobes narrowed behind, separated by an impressed line."

Horizon and Locality.—Grey shale of Div. 1 *c*. [1]. St. John, N.B. Canada. Scarce.

Size.—Length and width of the shields, 5 mm.

Tullberg says the name is derived from the projecting spine on the rachis of pygidium, "directed backward and upward" [but the back of the glabella is said to be very tumid ("tumidissimum")].

The varieties and forms included under this species by Swedish geologists allow one to consider it a flexible species, liable to considerable change of form. It is thus capable of including two forms which we have described in the Transactions of the Royal Society of Canada as separate species; there is the more

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reason for this since we have discovered that the pygidium referred provisionally to one of these forms (*A. partitus*) is of a different type from the usual pygidium of a Longifrontes, and therefore should be referred elsewhere; we have consequently included under this species, *A. partitus* and *A. acutilobus*.

Var. PARTITUS. Plate xvi., fig. 7.

Agnostus partitus. Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 68, pl. viii., fig. 2*a* (*not* 2*b*).

Cephalic shield elongate semi-elliptical. Dorsal furrow distinctly impressed; marginal fold sharp and narrow. Glabella cylindro-conical, obtusely pointed in front, expanded at the base; anterior lobe obtusely pointed, less than a third of the glabella's whole length; posterior lobe strongly elevated and obtusely pointed behind; basal lobes triangular, depressed to the level of the cheeks. Cheeks somewhat narrower in front than at the sides; divided in front by a distinct furrow that connects the dorsal and marginal furrows.

The heads of this variety are hardly distinguishable in form from the next, but they are all small, and it is found with an older subfauna; it is therefore kept separate. The pygidium is unknown.

Size.—Length and width of the head shield 2½ mm.

Horizon and Locality.—The grey shales of Div. 1 *c*, [1], at Porter's Brook and Hanford Brook, St. Martins, N. B., Canada. Infrequent.

Var. ACUTILOBUS. Plate xvi., fig. 8.

Agnostus acutilobus, Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 73, pl. vii., fig. 10.

Body elliptical elongate. Cephalic shield semi-elliptical, somewhat longer than wide. Dorsal furrow lightly impressed. Marginal furrow and fold sharply defined. Glabella subconical, widest behind, obtusely pointed in front; at the widest part of the posterior lobe it is one-third of the width of the head shield, and its length is about three-fourths of that of the head shield; the glabella is divided into four lobes, of which the anterior is one-third of its length and is subtriangular; the posterior lobe extends to the base of the shield. It bears an elongated ridge on the anterior half, where it is higher than it is behind; two faintly marked lateral furrows are just discernible on the lateral edges of this lobe. The two basal lobes of the glabella are comparatively large; they are divided from the rest of the glabella by a sigmoid furrow, and are depressed below the level of the

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glabella. The occipital ring is narrow, and is concealed beneath the projecting posterior extremity of the glabella. The cheeks are somewhat full, especially in front, and are divided by a furrow that connects the dorsal and marginal furrows, and each cheek is seamed across by a fainter furrow.

The thorax consists of two segments, of which the first bears five lobes; the two outer pairs of these lobes are globose, and the central one is semicircular and is crossed in the middle by a light furrow transverse to the axis of the thorax. The second segment of the thorax has three lobes, of which the two outer are somewhat elongate, and each is marked by a light furrow; the central lobe is subrectangular, and is traversed by a furrow angulated on each side of the axis of the thorax, and beginning and terminating on the posterior side of the lobe.

The pygidium is subelliptical, and its width and length are about equal. The marginal fold and furrow are about as distinct as those of the head shield. The rachis is oblanceolate, nearly half as wide as the pygidium, and its length is about four-fifths of that of the pygidium; it is narrowed in the anterior third, and is crossed in that part by two transverse furrows similar in appearance and direction to those of the preceding variety. The included lobe bears an elongated tubercle; the posterior lobe of the rachis is conical. The lateral lobes of the pygidium are moderately elevated and meet behind the rachis.

Sculpture.—This variety appears to be smooth externally, but sometimes shows a granulated inner surface to the test; by its smoothness it is distinguished from the other Longifrontes that occur with it.

Size.—Length, 13 mm. Width, 5 mm.

Horizon and Locality.—Frequent in the fine dark shales of Div. 1 *d*, [1]. At Porter's Brook, St. Martin's, N. B.

This variety differs from the type of *A. gibbus* in its narrower rachis and the peculiar second lobe of the pygidium. It is the most widely diffused of the Longifrontes in the St. John group.

? Var.

A few pygidia which by their general form, and in the lobation and contour of the rachis, appear to be of this species are found with the above form, but they are spined on the margins. We do not know the head shield.

Dr. Henry Hicks' description of *A. scutalis* of the Menevian group in Wales agrees closely with that of *A. gibbus*, except that the cheeks of the head-shields, and the side lobes of the caudal shield are said to be covered with tubercles. This ex-

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cludes Hicks' species from *A. gibbus*, but not from *A. punctuosus* which is thus ornamented; the latter species, however, has confluent side-lobes to the caudal shield, while in *A. scutalis* these lobes are divided by a furrow. *A. Nathorsti* is another species that is tuberculate on the sides, and is also nearer the size of *A. scutalis*, but this species has the sides of the posterior lobe of the glabella furrowed, and has marginal spines to the pygidium, characters which are absent from *A. scutalis*; so we find ourselves unable to recognize Hicks' species in the *P. Davidis* subfauna of America.*

AGNOSTUS NATHORSTI, Broegger.

Agnostus Nathorsti, Broegg. Om Paradoxides skifrene red Krekling, p. 68, pl. v., fig. 1.

Agnostus exsculptus, Ang. part (*i. e.*, "pygidium") Palæontologia Scandinavica, p. 7, pl. vi., fig. 8 (Fide Tullberg).

Agnostus Nathorsti, Tullberg. Agnostus Arterna vid. Andrarum, p. 21, pl. i., fig. 9.

"Head rounded, enclosed by a subfiliform narrow marginal fold. Glabella bilobate, anterior lobe narrower than the posterior, oblong, equally rounded-acuminate. Posterior lobe almost equal in length to one-half of the head, impressed by two deep grooves on each side, rounded behind, pressed together and high, furnished with a raised point; basal lobes separated from the glabella by a posterior furrow, rounded, connected behind the glabella. Cheeks separated in front of the glabella, sculptured with longer or shorter lateral furrows."

"The rachis of the thorax has elliptical lateral tubercles. Pygidium rounded behind, furnished with a somewhat broader bidenticulate marginal fold. Rachis with three joints, pointed behind, front joint shorter than the others, slightly wider, divided into three parts by two longitudinal depressions; the middle joint keeled, produced backward into a point. Posterior joint rather long, squeezed in the middle part by an arched depression, ornamented with a small elevated point in the depression. Lateral lobes minutely granulated, narrowed behind, separated behind the rachis."

Size.—"Length and width of the shields, 4½ mm."

Horizon and Locality.—Dark shales of Div. $1d^1$. Porter's Brook, St. Martin's N. B., Canada, scarce.

Tullberg remarks in his work cited above, that the shield figured by Angelin as the pygidium of *Agnostus exsculptus* is really the head shield of this species (*A. Nathorsti*).

*Figures 13, 14, pl. v., referred to *A. scutalis* are not of this species, but represent some species of the Limbati section (a Fallax).

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Some examples from the St. John group have the axis of the pygidium long and a furrow behind, connecting the dorsal and marginal furrow; these agree more nearly with the European form. The following form, however, is more plentiful.

Var. CONFLUENS n. var. Plate xvi., fig. 9, *a* and *b*.

This form is found in the eastern part of the St. John Basin. It does not quite agree with Broegger's species, but differs in the following respects:

The head shield is less quadrate behind, the furrows on the sides of the posterior lobe of the glabella less undulate, the basal lobes longer. The pygidium is more quadrate, the posterior margin less arched, the posterior lobe of the rachis is shorter and wider than in the type, and the side lobes are *not* separated behind the rachis by a furrow.

Sculpture.—The surface of the test especially in the head shield is radially wrinkled.

Size.—Length and width of each shield, about 4 mm.

Horizon and Locality.—Dark gray shales of Div. 1 d^1, at Porter's Brook, St. John county, N. B.

AGNOSTUS FISSUS, Lundgren.

Agnostus fissus, Linrs. Om fauna i Kalken med Conoc. exsulens, p. 23, tafl. ii., fig. 34.

Agnostus fissus, Tullb. Agnostus arterna vid. Andrarum, p. 16, tafl. i., fig. 3, *a* to *d*.

"Head and pygidium shorter and wider [than *A. gibbus*]. Test scarcely smooth, uneven, marginal fold narrow. Glabella shorter, broader, bilobed. Anterior lobe no longer than wide, more or less blunt in front, cleft in front by a very delicate line, equal to the posterior lobe in width; posterior lobe short for its width, one depression visible on each side, reaching its greatest height a little in front of the middle of this part, where an elevated point can be seen. Basal lobes small, triangular, scarcely connecting behind the glabella. Cheeks separated by an obsolete furrow in front of the forehead, ornamented on each side by obsolete furrows."

"Pygidium short, round, without spines. Rachis with three joints, more acuminate than in the preceding, all the joints of almost the same width; lateral parts of the anterior joint thickened; middle joints slightly narrower than the rest, higher, keeled, ornamented with a point. In frout of the middle of the posterior joint are two lateral obsolete depressions, between which an elevated point can be seen. Lateral lobes are connected behind the rachis."

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Size.—" Length and width of the shields, 3½ mm.

Horizon and Locality.—Fine dark shales of Div. 1 d^1 (the highest layers) at Porter's Brook, St. Martin's.

The Latin description contains no reference to the thorax; this is described in the next paragraph (Swedish). "First joint of the thorax somewhat smaller than the second, rachis with two tubercles at the sides; the pleuræ of the first joint are divided into a larger front tubercle and a smaller back tubercle by a furrow; the tubercles on the pleuræ of the posterior joint are of about the same size.

Var. TRIFISSUS n. var. Plate xvi., fig. 10.

This is about the same size as the type, and is distinguished by two additional furrows at the front of glabella, one at each corner, beside the median furrow that characterizes the type; these furrows cut into the cheeks in front of the glabella; the median furrow is the longest, but none connect with the anterior marginal furrow (or the median one, rarely). There are two minute tubercles at the axial line of the first lobe of the rachis of the pygidium.

Horizon and Locality.—In the Davidis Subzone at Chapel Arm, Trinity Bay, Newfoundland. Also in the Abenacus Subzone (Div. 1 d^1) at Porter's Brook, St. Martin's, N. B.

Development of the Young.—At the ½ mm. stage (1¼ mm. for the complete animal) the head shield already shows the cleft fore-lobe of the glabella, and a shallow indentation across the glabella marking off the first somite of the posterior lobe; the basal lobes are scarcely yet visible. The thorax has only one joint; this joint has tubercles on the sides of the rachis and a furrow on the pleura running directly outward; no pleural tubercles. The rachis of the pygidium is not lobed, but the somites are indicated by the incipient keel of the second lobe, and a very minute tubercle near the front of the third lobe, indicating the third somite; at the front of the rachis is a strong transverse ridge, the "half joint" (articulating ridge) more prominent now than in later stages. The first somite of the pygidium is not yet visible, but it is separated in the 1¼ mm. stage (2½ mm. for the whole animal), when the rachis divides into three lobes. Only one joint of the thorax of this stage has been seen; it shows tubercles on the pleuræ as well as on the rachis. When the animal becomes 3 to 3¼ mm. long both joints appear in the thorax and the general features of the test are those of the adult; the basal lobes of the head shield are still very small.

These features of growth in *A. fissus* are based on examples

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from the Abenacus Subzone of the St. John group. It will be seen that from the earliest stages described, this species can be separated from others, and before the rachis of the pygidium is segmented, the minute tubercle on the third somite distinguishes the species from *A. Nathorsti*, which has this tubercle on the fourth somite; in the young of *A. fallax* it is on the third somite, as in *A. fissus*, but becomes obsolete at a later stage in the former species.

Both the above variety and the type of *A. fissus* have been found at Porter's Brook, but only the variety at Chapel Arm. At Porter's Brook the species is known only from the highest fossiliferous beds of Division 1 *d*; so perhaps did not come to America with the first migrants of the Abenacus Sub-fauna.

AGNOSTUS PUNCTUOSUS, Angelin. Plate xvi., fig. 11.

Agnostus punctuosus, Ang. Paleontolog. Scand., p. 8, tab vi., fig. 11.

Agnostus punctuosus, Broegg. Om Paradox'skifr. v. Krekling, p. 67, tab. vi., fig. 12 *a* and *b*.

Agnostus punctuosus, Tullb. Agnostus arterna., p. 17, tab. i., fig. 5 *a* to *d*.

Angelin's description of this species is very brief, the following is Tullberg's:

"Test of both shields granulated. Marginal fold narrow. Glabella bilobate. Anterior lobe narrower than the posterior, subtriangular, divided lengthwise by a fine line sometimes scarcely visible. Posterior lobe ornamented on each side in front of the middle by a depression, and between these depressions by an elevated point, furnished behind the middle of the basal lobes with higher tubercules resting on lateral depressions, rounded behind. Basal lobes elongate, triangular, divided into two tubercles by a lateral depression, uniting behind the glabella. Cheeks separated in front of the glabella, furnished with lateral furrows not deep, slightly undulate, and with small points. Thorax with two joints, rachis ornamented with contiguous lateral tubercules, pleuræ divided into two tubercles by a transverse line.

"Pygidium without spines. Rachis three-jointed; anterior joint shorter and broader than the others; middle joint higher than the others, hexagonal, keeled, adorned with an elevated point; posterior joint elongated, round-acuminate, sometimes bordered by straight lines so as to become quite pointed; often furnished at the middle with a minute point, and below it lateral depressions. In the adult the lateral lobes connect behind the rachis, in the young state they are separated by a fine line; the

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lobes are densely granulated. In one pygidium the first joint [of the rachis] has two lateral elevated points, the middle joint near the strongly elevated carina has a point on each side, and the last joint is ornamented with an elevated point on each side in front, and one median point."

Size.—Length and width of the shield 6 mm.

Horizon and Locality.—In America this species is found at Highland Cove, Trinity Bay in company with *P. Davidis*, etc.

This fine species is easily recognized by its tuberculate side lobes and smooth rachis, and corresponding conditions in the head-shield. The somites in the third lobe of the rachis are clearly distinguishable in the American, as in the Norwegian examples, and the paired somites in this lobe are parallel to those seen in *A. Nathorsti*, etc.

AGNOSTUS LÆVIGATUS, Dalman.

Battus lævigatus, Dalm. Vetensk, Skad. Årsber, p. 136.

Battus lævigatus, Hisinger. Lethea Svec., p. 30, tab. iv., fig. 7.

Agnostus lævigatus, Ang. Pal. Scand, p. 6., tab. vi., fig. 3.

Agnostus lævigatus, Broegg, Om. Paradox. skifren p. 74, tab. v., fig. 6, and tab. vi., fig. 5.

Agnostus lævigatus, Tullb. Om. Agnostus-anterna, p. 27, tab. ii., fig. 17 *a* and *b*.

The following is Tullberg's description of this species: "Crust usually very smooth and handsome. Head-shield elongate-rounded, encircled by a narrow filiform marginal fold. Glabella obsolete in front, enclosed by impressed lines behind, rounded behind and ornamented with an elevated point. Basal lobes rounded, connected behind the glabella. Lateral furrows sometimes indent the cheeks. Pygidium elongate rounded, enclosed by a marginal fold which is broader behind. Rachis vanishing backward, the first joint obsoletely three parted, the second ornamented with an elevated point, the third narrow, scarcely distinguishable."

Size.—Length of the shields, 5 mm.; width, 4 mm.

Horizon and Locality.—Head shields of this species occur in limestones at Chapel Arm, Trinity Bay, Newfoundland. As we have no pygidium they may be of the following variety.

Var. TERRANOVICUS n. var. Plate xvii., figs. 1 *a* and *b*.

This variety has the narrow marginal fold of the typical form, but differs in the larger basal lobes of the glabella, and in having the rachis of the pygidium defined throughout by a distinct furrow. In this respect it approaches more nearly the variety

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forfax of Broegger, which also has the pygidial axis thus defined; but this axis in the Norwegian variety is longer and is not divided into lobes. In var. *terranovicus* the front lobe of the pygidium is separated by a furrow from the rest of the rachis, but there is no middle lobe except in so far as it is indicated by a tubercle about one-third from the front. The side lobes of the pygidium are wider than in var. *forfax*.

Sculpture.—The test is minutely punctate.

Size.—Length and breadth of each shield, 5 mm. Rachis of pygidium, 4 mm. long, 2 mm. wide.

Horizon and Locality.—Dark siliceous slate of Highland Cove, Trinity Bay, Newfoundland, with *P. Davidis*.

Var. CICEROIDES n. var. Plate xvii., fig. 3 *a* and *b*.

This is a smaller and more tumid form than the preceding, and the rachis of the pygidium is wider in proportion; the middle lobe of the rachis is marked off from the posterior by a faintly impressed line, and bears a more prominent tubercle than the preceding variety.

Sculpture.—As the preceding.

Size.—Length and width of each shield, 3½ mm. Rachis of pygidium, 2½ mm. long, 1½ mm. wide.

Horizon and Locality.—Found with the preceding.

The head shield of this variety is like that of *A. Cicer*, Tullberg, but it is furnished with a marginal fold; that species also has a wider and only partially defined rachis to the pygidium.

Var. MAMILLA, n. var. Plate xvii., figs. 3 *a* and *b*.

Nearly the same size as the preceding. It has more distinct basal lobes, but the difference is chiefly in the pygidium; the rachis is undivided and greaty elevated at the second somite where there is a prominent tubercle one-third from the front of the rachis; the lateral lobes are divided by a furrow, and the posterior marginal fold is wide.

Sculpture.—As the preceding but with small scattered tubercles on the head shield.

Size.—Length and breadth of the shields, nearly 4 mm. Rachis of the pygidium: length, 2½+mm.; width, 1½+mm.

Horizon and Locality.—Found with the preceding.

While the head of this variety is that of a Lævigatus, the pygidium is nearly that of a Parvifrons; in the latter, however, the dorsal and marginal furrows of the pygidium are confluent, in this variety they are distinct, but connected by a cross-furrow. But for the absence of glabella this variety would closely resemble Broegger's var. *mamillatus* of *A. parvifrons*.

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In *Agnostus Barrandei*, Salter, of the Menevian horizon in Wales we evidently have a species of the Lævigati section, and although Dr. Hicks' figure* does not show any rim, the description indicates that there was one; from this and the pygidial features this species appears to be allied to *A. lævigatus*, rather than *A. nudus;* but judging from these features, also the two individuals figured must at least be of different varieties; Fig. 5, if we be guided by the form of the rachis, approaches var. *forfax*, and Fig. 6 var. *terranovicus;* the resemblance does not establish an identity in either case.

? AGNOSTUS NUDUS, Beyrich.

This species appears to be indicated by some head shields found in Newfoundland. The head shield is high at the back in the middle and arched down in all directions, and is devoid of marginal fold.

Sculpture.—Smooth and shining with a minutely punctate surface.

Size.—Length and width, 3 mm.

Horizon and Locality.—Limestone of Chapel Arm, Trinity Bay, Newfoundland.

MICRODISCUS, Emmons.

This genus, which in the small number of the pleural joints, is almost on a par with Agnostus—for the number varies from two to four for the different species—is characterized by certain changes of form from its earliest appearance until it died out in the later stages of the Paradoxides beds—changes which are comparable to those in Agnostus, but on different lines: one of these lines of development is the obliteration of the costæ on the side lobes of the pygidium, and the other the extraordinary development of the occipital spine.

The "great nuchal spine" as Salter calls it is not merely an extension of the summit of the occipital ring, but in some species at least it carries with it the posterior part of the glabella; hence these species have no proper occipital furrow, but the two outer ends of this furrow are seen to run a little way up the side of the spine or form a threadlike band at the the back of the spine; in such cases the main furrow seen at the base of the spine is in reality the posterior glabellar furrow, and this lighter furrow behind is the occipital furrow.

The obliteration of the occipital furrow in many species of this genus leaves one less than the normal number of furrows on the axis of the head shield, so that usually not more than three,

*Quart. Jour. Geol. Soc., London, May '72, p. 176, pl. V., Figs. 5 and 6.

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sometimes only two, can be discerned. All the furrows are usually indistinct or even obliterated in the later species of the Paradoxides Beds, in the adult shields; but even in these there are often impressions of these furrows on the inner surface of the test.

It is in the species of the Olenellus Zone that the series of furrows marking the somites is most clearly seen. *M. speciosus* for instance has three pairs of broadly, but distinctly impressed furrows on the sides of the glabella and also a pair of sharply cut occipital furrows.* In *M. lobatus* the furrows of the glabella are not quite so obvious, and the posterior of the three is usually very indistinct, but the number is the same as in the preceding species.

Both Agnostus and Microdiscus exhibit larval characters in the anterior lobe of the glabella, the former by the large size of the anterior lobe (as in Regii) or its distinctness (as in Fallaces and Longifrontes). In Microdiscus, however, the larval facies is maintained by the large size of the anterior lobe as compared with those behind it. The Ptychparidæ in the Protaspis stage, which the author has studied, agree in having the somites of the cephalic axis short except the front one which is much larger and longer than the others; as regards the length, this is a permanent characteristic in the typical Microdisci of the Olenellus zone, for in these the front lobe is nearly as long as the other three.†

As in Agnostus, and in many other trilobites the pygidium of Microdiscus is divided into an anterior and a posterior part, the latter distinguished by the imperfect segmentation of the rachis; this is very well seen in the section (Eodiscus) described hereafter, wherein the protopygidium is marked by a tubercle on the summit of each ring of the rachis, while on the neo-pygidium there is a row of low tubercles along the crest of the ring, similar to those on the lateral lobes (of *M. pulchellus*, etc.). The pygidium in this group by the appearance and subsequent effacement during growth of costæ on the side lobes shows the addition of somites beyond the number of those of the early stages; while in other sections as Dawsonia (see below) the surface moulding shows the cementing of additional segments to the front of the pygidium.‡

A general rule holds in the genus Microdiscus as to the increase of the number of rings in the rachis of the pygidium, according to the geological age of the species; the majority of those

*On many heads of adult examples of *M. speciosus* all these furrows are quite obliterated.

†*M. speciosus* and *M. lobatus*, but this is not the case with *M. Schucherti* in which this lobe is short as in the Microdisci of the Paradoxides beds.

‡See also the pygidium ascribed to *M. precursor*.

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of the Olenellus zone have but few rings (4 to 6), but in the Paradoxides zone, species with many rings (8 to 10 or even 12), are multiplied. The late Prof. C. F. Hartt recognized the distinction between these two sections of the genus as it occurs in the Paradoxides beds, giving to one the name Dawsonia and to the other Eodiscus. The following scheme will show how the species of Microdiscus are related to each other:

long glabella	Lateral lobes of pygid. ribbed	occipital ring obtusely pointed	Pygidial rachis has 4 rings	Section LOBATUS lobatus, Hall, 1847*	Horizon.
	pygidium unknown		unknown	Meeki, Ford, 1876	Olenellus Zone.
	ribbed		6 rings	Parkeri, Walc., 1886	
	smooth		6 rings	Helena, Walc., 1889	
	smooth		12 rings	Section SPECIOSUS speciosus, Ford, 1874	Olenellus Zone.
	smooth		10 rings	bellicinctus, Shaler & F, 1888	
short glabella	several costæ on the pygidium	occipital ring spined	6 to 7 rings	Section DAWSONIA† Dawsoni, Hartt, 1868	Paradoxides lamellatus Sub-zone.
			6 rings	sculptus, Hicks, 1871	
	no costæ on the side lobes of the pygidium.	occipital ring obtusely pointed	6 rings	Section EODISCUS‡ Schucherti, n. sp.	Olenellus Zone.
			6 rings	connexus, Walc., 1887	olenel. z. (?)
			unknown	precursor, Matt., 1885	Paradoxides eteminicus.
			12 rings	suecicus, Linrs., 1892	Sub-zone.
		occipital ring spined	12 rings	pulchellus, Hartt, 1884	P. Abenacus sub-zone.
			10 rings	punctatus, Salter, 1864§	Paradoxides.
			9 rings	eucentrus, Linrs., 1882	Davidis sub-zone.

* First published as an Agnostus.
† Used by Hartt for *M. Dawsoni*, published by Dawson, 1868.
‡ Name used by Hartt (probably about 1870), not published until 1884.
§ The type of the genus.

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The embryonic tests of individuals of the section Eodiscus do not show any characters special to the genus, but these speedily appear in very small larval tests, and are first recognizable in the headshield. In general outline and in having costal ribs on the sides of the pygidium, this part of a young Eodiscus is much like that of a Ptychoparia at the corresponding stage, but in the later moults the distinctive features of Microdiscus appear; the rings of the axis become more numerous, the pleural lobes inflated and the form of the pygidium more elongated. In the species of this section (Eodiscus) the furrow on the pleuræ (of the posterior joint at least) run forward and outward as in Agnostus; this is perhaps due to the strong geniculation of the anterior marginal fold of the pygidium, necessitating a convexity of the overlapping pleura.

The genus Microdiscus serves as a link between the Paradoxides and the Olenellus faunas, and there is a gradation of resembling species through two lines of development, one with few, the other with numerous joints in the rachis of the pygidium. Though Microdiscus is so common in the Olenellus Fauna and passes into that of Paradoxides, no example has been found in the Protolenus Fauna.

MICRODISCUS SCHUCHERTI n. sp. Plate xvii., figs. 4 *a* and *b*.

Headshield subcircular, one-quarter wider than long, flattened in front, drawn in and upturned at the genal angles; axis projecting behind. Anterior marginal fold enclosing a flattened area, which is indented in front of the glabella. Glabella two-thirds of the length of the shield, cylindro-conical, depressed in front, elevated and projecting backward behind; three pairs of furrows faintly impressed on the sides. Occipital ring not visible. Cheeks moderately arched, not meeting in front of the glabella. Posterior marginal fold wide at the outer end, shield narrower here than opposite the cheeks.

Thorax not known, but the relief of the approximate margins of the two shields indicates a prominent rachis and strongly geniculate pleuræ, with furrows directed forward.

Pygidium longer in proportion than the head shield, and more decidedly arched. Rachis nearly three-quarters of the length of the shield; it has about six joints, the anterior four prominent and each crowned with a tubercle. Side lobes sloping down to a flattened marginal fold, which is strongly geniculated in front, with an almost vertical outer slope.

Sculpture.—Surface of both shields minutely granulate.

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Size.—Length of pygidium, 3 mm.; width, 4 mm.; the head-shield is somewhat shorter.

Horizon and Locality.—Limestone of the Olenellus Zone at Troy, N. Y. Collected by Mr. C. Schuchert and communicated to the author.

Though this species is not of the Paradoxides Zone, I have described and figured it here on account of its resemblance to the larval stages of certain Microdisci of that zone. It differs from others with which it occurs in its short glabella and broad, depressed head shield; in these points it is like *M. Dawsoni*. While the typical species of the Olenellus Zone have retained the occipital ring, it appears to be wanting or nearly effaced in this species, as in several species of the Paradoxides Zone, and in the Agnosti. The larval pygidia of the Eodisci (*M. pulchellus*, etc.) resemble the adult shield of this species in contour, number of rings in the rachis, etc. And it is to a fixed larval stage of this type, rather than to *M. pulchellus*, *M. punctatus* or *M. Dawsoni* that the author would look as the source of such a form as *M. connexus*, Walc.; for this species differs little from *M. Schucherti*, except in the extension of the occipital spine. All our examples of *M. Schucherti* show only the outer surface, and so it is not known whether the border fold of the head shield is crenulated within.

MICRODISCUS PRECURSOR. Plate xvii., fig. 7.

Microdiscus punctatus var. *precursor*, Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 75, pl. vii., fig. 13.

Only the head shield of this species is with certainty known. It resembles *M. pulchellus*, but is more triangular in outline. The marginal rim is very narrow; the dorsal furrow is deep and wide and connected with the marginal furrow by a shallower furrow. Glabella shows two faint pairs of furrows at the sides,

Microdiscus precursor, supposed pygidium mag. 4. (This figure should have been placed between figs. 4*b* and 8*d* on Plate xvii.)

on the inside of the test, smooth on the outside. The occipital ring bears a tubercle or short spine. The cheeks are tumid, nearly straight on the side next the dorsal furrow, to which they descend abruptly; at the posterior inner corner is a prominence which projects toward the glabella in front of the occipital ring.

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Occurring at the horizon of this species there is a somewhat long semi-circular pygidium which may belong to this species; a young example possesses the following characters. It is one and a-half times as wide as long. Rachis narrow and prominent, about one-fifth of the width of the shield, and three-quarters of its length; two rings are divided off the front by transverse furrows, two others are marked by side furrows, and there is a posterior lobe twice as long as wide, not reaching the marginal fold. The side lobes are tumid and are traversed by transverse furrows; three in front have the appearance of anchylosed segments of the thorax; one behind is less distinct, and a fifth is faintly indicated. A low, narrow, obscure fold goes around the margin of the shield.

Sculpture.—There are minute scattered tubercle on the cheeks and glabella, and minute, rather obscure crenulations on the inner surface of the test at the marginal fold. The supposed pygidium is minutely granulated.

Size.—Length of the head shield, 2 mm.; width, 1½ mm.

Horizon and Locality.—In the fine gray shales of Div. $1c^2$ at Hanford Brook and Porter's Brook, St. Martin's, N. B., Canada.

This species has a general resemblance to *M. scanicus* of the Swedish Paradoxides beds as regards the head shield; but if the pygidium described above belongs here, the species is more nearly related to *M. Dawsoni* and *M. Schucherti*; the crenulations of the margin are similar to those of the section Eodiscus, but not so sharply marked or so noticeable.

MICRODISCUS DAWSONI, Hartt. Plate xvii., figs. 5 *a* to *e*.

Microdiscus Dawsoni, Hartt. Acad. Geol., 2d ed., p. 564, fig. 228.

Microdiscus Dawsoni, Walcott, U. S. Geol. Surv. Bull 10, p. p. 23, pl. ii., figs. 3 and 3*a*.

Microdiscus Dawsoni, Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 75, pl. vii., figs. 11, *a* to *c*.

Description.—"Cephalic shield semilunar, with thickened border, crossed by numerous grooves running perpendicularly to the circumference. Glabella convex, narrow, rounded in front, conical and pointed behind, projecting beyond the posterior border, without furrows or occipital groove. Cheeks convex, no eyes and no traces of sutures, posterior angles of the shield with backwardly projecting spines. Pygidium subtriangular, with curved outlines, rounded in front and behind; middle lobe distinctly marked and divided into six segments; lateral lobes also divided; furnished with a narrow border."

This is one of the most characteristic species of the P. lamel-

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latus Subzone. The head shields in my examples are broadly semicircular; the glabella and cheeks slope downward in front below the level of the anterior marginal fold, which rises in front as a prominent, crenulated, transverse ridge; the glabella extends backward into a stout spine, slightly hooked downward at the extremity; the glabella and spine form together a fusiform axial lobe tapering to both ends, and the two parts are nearly on the same plane.

The thorax consists of two joints having rounded rings and the pleuræ have broad furrows directed forward as in Agnostus.

The pygidium is angled in front, has seven segments in the rachis and five ribs on the lateral lobes, of which the posterior are strongly directed backward as on the Welsh *M. sculptus*, Hicks.

Sculpture.—This species is closely granulated on those parts of the test that are raised above the general surface, but not in the furrows.

Size.—Length of head, exclusive of spine, 3 mm.; width, 4 mm. Length and width of pygidium, the same. The occipital spine is 2 mm. long.

Horizon and Locality.—The fine gray shales of Div. 1 c^1 at St. John, Ratcliff Stream, Simonds' and Hanford Brook, St. Martin's, N. B., Canada, but nowhere plentiful.

Development of the Young.—The young head shield in this species differs widely from the adult. At the length of 1 mm. the front rim is narrow all around and no crenulation is visible; the cheeks are comparatively flat, and there is a flattened area within the rim indented with a depressed point in front of the glabella, which it touches as in *M. Schucherti*. The glabella is pointed behind but bears no spine. The genal angles are somewhat pointed. At $1\frac{1}{4}$ mm. length of head shield, the rim begins to widen in front and shows shallow crenulations, and the flattened area still shows a depression in front of the glabella. The genal angles are sharp and the posterior marginal fold broadens at the end and is upturned as in *M. Schucherti*. The glabella has a long anterior lobe, as *M. speciosus* has in the adult stage. In the later moults the strongly crenulated widened margin and the development of the occipital spine easily distinguish this species from the former of those above named, and the breadth of the shield and wide anterior rim from the latter.

I have not met with the genal spines described by Prof. Hartt, but the indrawn and upturned genal angle of the head shield forcibly recall similar features in more than one species of Microdiscus of the Olenellus Zone.

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Although the pygidium of our species and that of *M. sculptus* are alike, the head shields are quite different, and the number of thoracic joints differs.

MICRODISCUS PULCHELLUS, Hartt. Plate xvii., fig. 8 *a* to *f*.

Microdiscus punctatus (Salter) Whiteaves. Am. Jour. Sci., 3 ser., vol. xvi., p. 225.

Microdiscus pulchellus, Hartt, Ms. in List to Sir J. W. Dawson.

Microdiscus punctatus, Walcott, U. S. Geol. Surv., Bull. 10, p. 24, pl. ii., figs. 1 *a* to *c*.

Microdiscus punctatus var. *pulchellus*, Trans. Roy. Soc. Can., vol. iii., pt. iv., p. 74, pl. vii., figs. 12 *a*, *b* and *c*.

Description (by Mr. C. D. Walcott).—"Head semi-elliptical in outline, rather strongly convex, and bordered on the front and sides by a depressed furrow and raised rim, the furrow containing numerous short furrows perpendicular to the margin, as in *M Dawsoni*, but not as strongly marked. The posterior border is strong back of the cheeks, and has the furrow continuing from the sides; a very narrow rim extends back of the glabella; eyes and facial sutures entirely absent.

"Glabella elongate conical, extending backward in a strong spine, as long as the glabella in medium-sized specimens, and nearly as broad at the base. In some examples the spine is shorter and smaller. The glabella rises above the level of the cheeks, and is about three-fifths of the length of the head, bordered by strong dorsal furrows that are connected in front by a straight furrow with the depressed groove within the anterior marginal border, perceptibly marked by two pairs of oblique glabellar furrows in some examples. Cheeks convex, prominent, strongly defined by the dorsal and marginal furrows.

"Thorax unknown." [see below.]

"The pygidium, associated with the head of this species in great numbers, has the same general outline as the head. The narrow, margined rim is well defined all around, widest at the sides; anterior marginal furrow very distinct; median lobe elongate conical, extending back nearly to the marginal groove; nine anchylosed segments are indicated by eight rather strong, transverse furrows; lateral lobes strongly convex, no furrow appearing back of the anterior marginal groove."

Sculpture.—"Surface finely punctate, the punctæ being rather large as compared with the depth.

Size.—Dimensions of a rather broad head. Length, 3.5 mm. (also 4½ mm.). Pygidium, length, 3.75 mm. (also 4½ mm.).

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Breadth, 5 mm. There is considerable variation in the proportion of the parts.

"This is an abundant and well-marked species. The pygidium is very similar to that of *M. speciosus*, Ford, of the Olenellus Fauna. In event of the two forms *M. punctatus* and *M. pulchellus* proving distinct, I propose that Mr. Hartt's name, *M. pulchellus*, be given to the American species.

The following particulars may be added to the description of this form given by Mr. Walcott, in Bulletin 10.

The occipital spine is much more slender in the author's examples than in those figured by Mr. Walcott; it is flattened at the sides, and frequently rises from the plane of the head shield at an angle of 45°.

The short, transverse furrows on the marginal fold of the head shield differ from those of *M. Dawsoni* in being closer together and at about equal distances all around the margin; they are not on the outer surface of the fold. but only indent the inner surface of the test, hence they are not visible from above when the test is perfect.

No complete thorax has been found in connection with the shields, but the separated joints show a strong axial ring which has a row of obscure tubercles along the ridge similar to those on the posterior rings of the rachis; the pleuræ are strongly arched, and have a long and deep furrow directed somewhat obliquely backward; they seem not very rigid and terminate in rounded points.

According to Mr. Walcott the median lobe of the pygidium has eight segments, including the articulating ring, but well grown examples show nine well marked rings, and three other smaller, less distinct ones, near the end of the rachis. When one-quarter grown this species has seven distinct rings in the rachis, the number in the mature *M. punctatus*, according to Mr. Salter. From this species *M. pulchellus* differs not only in respect to the number of these rings, but also in having a smaller and more erect occipital spine.

Sculpture.—The test of *M. pulchellus* has been described as punctate, but this remark applies only to the head shield and thorax, for the pygidium is tuberculate on the side lobes. It may be added that the strong rings of the rachis carry each a low spine at the summit; but on the weak posterior rings the crest is ornamented with a row of small tubercles.

Size.—The dimensions given above are of the largest shields, more frequently it is a third smaller.

Development of the Young.—The change of this species as it grew from a Protaspis stage similar to that of other trilobites

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associated with it, is partly shown by immature tests that have been observed. It acquired generic characters at a very early stage so far as the head shield is concerned, but the pygidium took a longer time. The Protaspis (slightly over $\frac{1}{2}$ mm. in length) is remarkable for the equal spacing of the somites almost from the first, causing the first somite to be smaller, and the first furrow further forward than usual; while the cephalic portion of the axis is visibly segmented, the caudal is not, and the line of suture between the two shields is scarcely indicated; the rachis almost touches a faintly defined rim at the back of the shield. In the $\frac{1}{2}$ mm. stage of the head shield the glabella is already near the normal form in the adult, but extends farther forward, and the furrow in front is short and deeply impressed, as in the young of *M. Dawsoni* and the adult of *M. Schucherti;* there is a slender occipital spine elevated at an angle from the plane of the head shield as in the adult. When the head shield is 1 mm. long the crenulation on the interior of the front rim of this shield becomes visible, and very short genal spines are added to the posterior angles.

When the pygidium was $\frac{1}{2}$ mm. long it had three lobes in the rachis and one rib marked off by a faint furrow at the front of the lateral lobes; this furrow is distinct only in the middle of its length; at this stage the shield is much flatter and wider than the adult and is bordered by a broad rim, within which is a broad rounded furrow. The $\frac{3}{4}$ mm. shield does not differ much in form, but has four rings in the rachis, and the rib at the front of each cheek is more distinctly marked. In the $1\frac{1}{2}$ mm. stage there are seven lobes to the rachis and only a faint trace of the rib on the front of the side lobe. In the 2 mm. stage there are seven strong lobes and three faint lobes on the rachis, and no trace of the rib on the side lobe, so that at this stage the pygidium has nearly assumed the aspect of the adult shield.

Horizon and Locality.—All parts of the St. John Basin, in the beds carrying the Abenacus Sub-fauna Div. 1 d^1. Also in Kennebecases and Long Reach Basins at the same horizon.

Microdiscus punctatus, Salter.

Microdiscus punctatus, Salter, Quart. Jour. Geol. Soc. vol. xx., no. 79, p. 237, pl. viii., fig. 11.

c. f. *Microdiscus eucentrus*, Linrs. De Under Paradoxideslagren vid Andrarum, Stockholm, 1883, p. 30, tab. 4, figs. 19 and 20.

J. W. Salter's description of this species is as follows: "Head without eyes or facial suture; margined, the glabella and side lobes very prominent, punctate. An enormous nuchal spine.

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Body rings 4. Tail equal to the head, with a strong 7-ringed axis, and smooth punctate sides, margin distinct."

G. Linnarsson's description of *M. eucentrus* is the following: Equalling the preceding (*i. e. M. Scanicus*), but the head more convex; glabella without any occipital furrow behind, prolonged into a spine longer than the head.

Linnarsson's species is evidently very near to Salter's, if not identical with it; the Swedish naturalist points to the larger number of joints in the pygidium of his species as distinctive of it, also to the absence of the crenulate border of the head shield. But I think Salter's "7 rings" to the axis of the pygidium refers only to the more distinct joints in the main part of the axis; and as for the ornamentation of the front rim of the head shield (unless the Welsh are different from the American species) that exist *only on the interior of the rim*, and would not appear on the outer surface of the test.

The young tests of *M. punctatus* show almost the same progressive changes from the embryonic form as *M. pulchellus;* among these are the acquisition and subsequent disappearance of a rib on the front of the side lobes of the pygidium; occasionally two ribs are thus developed, but in the adult these larval ribs disappear.

Sculpture.—The surface both of the head shield and pygidium are ornamented with close punctures, differing thus from *M. pulchellus* in which the surface of the pygidium is covered with small tubercles, while the head shield only is punctate.*

Size.—Length of largest head, exclusive of spine, 5 mm., length of spine 5 mm. (smaller heads show a spine longer in proportion); width of head shield, 6 mm. The pygidium is of the same size (excluding the occipital spine).

Horizontal and Locality.—In the fine gray shales of the P. Davidis Subzone at Manuel Brook, Conception Bay, Newfoundland. Common.

Explanation of Plates.

PLATE XIV., Cirripedia, Etc.

Notation of the horizons, used below:

Div. $1c^1$. Horizon of Paradoxides lamellatus.
Div. $1c^2$. Horizon of Paradoxides Eteminicus.
Div. $1d^1$. Horison of Paradoxides Abenacus.
Div. $1d^2$. Horizon of Paradoxides Davidis.

Fig. 1. *Stenotheca concentrica.* Flattened and cracked along the back. Mag. ½. From Div. $1\,d^1$, St. Martins, N. B. See p. 201.

* Pygidia occur, however, at Chapel Arm, Trinity Bay, Newfoundland, in the P. Davidis Subzone, having the surface tuberculate; the species has not been determined.

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FIG. 2. *S. concentrica* var. *radiata*. Mag. $\frac{1}{1}^0$. From Div. 1 *c*, St. John, N. B. See p. 202.

FIG. 3. *Stenotheca Hicksiana*. Mag. $\frac{1}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 205.

FIG. 4. *Stenotheca triangularis*. *a*, a cast of, showing the outline of the cone and the thickened apex. *b*, a cast without the outline. Both mag. $\frac{1}{1}$. From Div. 1 c^2, St. John, N. B. See p. 203.

FIG. 5. *Strobilepis spinigera*, J. M. Clarke. Terminal plate (and penultimate plate in outline). Figured for comparison from Dr. Clarke's restoration. Mag. $\frac{1}{2}$. The terminal plate is partly covered by the penultimate. Devonian species. See p. 203.

FIG. 6. *Stenotheca nasuta*. *a*, small example, mag. $\frac{1}{1}$. *b*, original type mag. $\frac{1}{1}$. Both from Div. 1 *c*, St. John, N. B. See p. 204.

FIG. 7. *Plumulites Manuelensis*, n. sp, mag. $\frac{1}{1}$. From Div. 1 d^2, Manuel Brook, Newfoundland. See p. 200. (Misprinted Plate XV. on p. 200.)

FIG. 8. Cirripedian and other plates. Type A, *a* and *b*, two forms of oval plates. Type B, *a*, ribbed plate; *b*, smooth plate. Type C, *a*, plate with deep furrow; *b*, plate with high umbo; *c*, plate with eared flange; *d*, plate similarly flanged but more regular; these are perhaps Cystidian. Type D, symmetrical plate, perhaps one of the axial row of plates. Type E, triangular plate with radiating ridges (possibly cystidian). Type F, triangular plate with arched keel (*Cirropodites Cambrensis*). Type G, triangular plate with facetted edges. All the figures except 8 G, a, mag. $\frac{2}{1}$ 8 G, a, is mag. $\frac{1}{1}$. The narrow figures beside the larger ones are sections. See p. 206.

PLATE XV., OSTRACODA AND AGNOSTUS (part).

FIG. 1. *Lepiditta alata*. *a*, outer surface of left valve. *b*, cast of interior of right valve. Mag. $\frac{2}{1}^0$. From Div. 1 c^2, St. John, N. B. See p. 194.

FIG. 2. *Lepiditta curta*. Interior of left valve. Mag. $\frac{1}{1}^0$. From Div. 1 d^1. St. Martin's, N. B. See p. 195.

FIG. 3. *Lepiditta auriculata*. *a*, left valve showing faint concentric lines and the ligamental (?) groove at the hinge. *b*, same, hinge line in profile. Mag. $\frac{1}{1}$. From shales of Div. 1 *c*, St. Martin's. See p. 196.

FIG. 4. *Aluta flexilis* n. g. et sp. left valve (with lower margin restored) showing ocular (?) tubercle, Mag. $\frac{2}{1}$. From conglomerate limestone band in Div. 1 c^1, St. Martin's, N. B. See p. 198.

FIG. 5. *Primitia Acadica*. *a*, left valve. *b*, longitudinal section. *c*, transverse section. Mag. $\frac{2}{1}$. From Div. 1 c^1, St. Martin's, N. B. See p. 196.

FIG. 6. *Agnostus fallax* var. *vir*. Complete, somewhat flattened. Mag. $\frac{1}{1}$. From Div. 1 c^2, St. John, N. B. See p. 215.

FIG. 7. *A. fallax* var. *concinnus*. *a*, head shield. *b*, a joint of the thorax. *c*, Pygidium. Mag. $\frac{1}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 216.

FIG. 8. Same variety. *a*, head shield of young larva retaining embyonic (Protaspis-like) features. Mag. $\frac{2}{1}^0$. *b*, young pygidium showing somites and posterior tubercle on rachis, effaced in later stages. Mag. $\frac{1}{1}^0$. Both from Div. 1d^1, St. Martin's, N. B. See p. 216.

FIG. 9. *A. fallax* var. *trilobatus*, n. var. Pygidium. Mag. $\frac{1}{1}$. From Div. 1 c^1, St. John, N. B. See p. 216.

FIG. 10. *Agnostus Acadicus*, Hartt. *a*, head shield. *b*, pygidium. Mag. $\frac{1}{1}$. From Div. 1 c^1, St. John, N. B. See p. 217.

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FIG. 11. *A. Acadicus* var. *declivis*. *a*. head shield. *b*, pygidium. Mag. $\frac{1}{1}$. *c*, larval pygidium showing embryonic features. Mag. $\frac{1}{1}$. *d*, adult pygidium in the rachis of which are six somites. Mag. $\frac{1}{1}$. All from Div. 1 d^1, St. Martin's, N. B. See p. 219.

PLATE XVI., AGNOSTUS.

FIG. 1. *Agnostus regulus*. *a*, head shield. *b*, a joint of the thorax. *c*, Pygidium. Mag. $\frac{1}{1}$. From Div. 1 c^2. See p. 213.

FIG. 2. *Agnostus rex* Barr. var. *transectus* n. var. Pygidium, Mag. $\frac{1}{1}$. From Div. 1 d^1, St. Martin's. See p. 214.

FIG. 3. *Agnostus parvifrons* Linrs. var. *tessella*. *a*, head shield. *b*, thorax. *c*, pygidium, Mag. $\frac{1}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 221.

FIG. 4. *Agnostus umbo*. *a*, head shield. *b*, pygidium. Mag., $\frac{1}{1}$. From Div. 1 d^1, St. Martin's N. B. See p. 222.

FIG. 5. *Agnostus obtusilobus*. Mag. $\frac{1}{1}$. From Div. 1 d^1. St. Martin's N. B. See p. 223.

FIG. 6. *Agnostus Davidis*, Hicks. Pygidium. Mag. $\frac{1}{1}$. From Div. 1 d^2, Manuel Brook, Newfoundland. See p. 225.

FIG. 7. *Agnostus gibbus*, Linrs. var. *partitus*. Head shield. Mag. $\frac{1}{1}$. From Div. 1 c^2, St. Martin's, N. B. See p. 227.

FIG. 8. *A. gibbus* var. *acutilobus*. Mag. $\frac{1}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 227.

FIG. 9. *Agnostus Nathorsti*, Brögg, var. *confluens*, n. var. *a*, head shield. *b*, pygidium. Mag. $\frac{1}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 230.

FIG. 10. *Agnostus fissus*, Lundgr. var. *trifissus*, n. var. Mag. $\frac{1}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 231.

FIG. 11. *Agnostus punctuosus*, Ang. *a*, head shield. *b*, pygidium. Mag. $\frac{1}{1}$. From Div. 1 d^2, Highland Cove, Newfoundland. See p. 232.

PLATE XVII., AGNOSTUS AND MICRODISCUS.

FIG. 1. *Agnostus lævigatus*, Dalm., var. *terranovicus*, n. var. *a*, head shield. *b*, pygidium. Mag. $\frac{1}{1}$. From Div. 1 d^2, Highland Cove, Newfoundland. See p. 233.

FIG. 2. *A. lævigatus* var. *mammilla*, n. var. *a*, head shield. *b*, pygidium. Mag. $\frac{1}{1}$. From Div. 1 d^2, Highland Cove, Newfoundland. See p. 235.

FIG. 3. *A. lævigatus* var. *ciceroides*, n. var. *a*, head shield. *b*, pygidium. Mag. $\frac{1}{1}$. Found with the preceding. See p 234.

FIG. 4. *Microdiscus Schucherti* n. sp. *a*, head shield. *b*, pygidium. Mag. $\frac{1}{1}$. From Olenellus limestone, Troy, N. Y. See p. 238.

FIG. 5. *Microdiscus Dawsoni*, Hartt. *a*, head shield. *b*, same in profile. *c*, pygidium. Mag. $\frac{1}{1}$. *d*, young larval stage, head shield. Mag. $\frac{10}{1}$. *e*, next larval stage, head shield. Mag. $\frac{10}{1}$. All from Div. 1 c^1, St. John, N. B. See p. 240.

FIG. 6. *Microdiscus speciosus*, Ford. head shield. Mag. $\frac{1}{1}$. From Olenellus limestone, Troy, N. Y., figured for comparison. See p. 236.

FIG. 7. *Microdiscus precursor*. Head shield. Mag. $\frac{1}{1}$. From Div. 1 c^2, St. Martin's, N. B. See p. 239.

FIG. 8. *Microdiscus pulchellus* Hartt. *a*, head shield. *b*, same in profile. *c*, pygidium. Mag. $\frac{1}{1}$. *d*, embryonic or Protaspis stage. Mag. $\frac{10}{1}$. *e*, early larval stage. *f*, pygidium of same. Both Mag. $\frac{20}{1}$. All from Div. 1d^1, St. Martin's, N. B. See p. 242.

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ON THE EXISTENCE OF PRE-CAMBRIAN AND POST-ORDOVICIAN TRAP DIKES IN THE ADIRONDACKS.

By H. P. Cushing.

Contents.

	PAGE.
Introduction	248
Present Rock Classification	248
Proposed Change in the Classification	249
The Dikes	249
Description	249
Distribution	250
Scarcity north of the Adirondacks	251
Summary	252

Introduction.

As one commences field work in the eastern Adirondacks, the numerous dikes of the region early thrust themselves on the attention, and as they are studied and mapped certain facts regarding their distribution become obvious and demand explanation. These facts are more prominently brought out in Clinton county, N. Y., where the writer has been at work, than is the case in Essex county and in western Vermont, where the dikes have been so thoroughly studied by Prof. Kemp, though many of them have been noted and published by him. In the writer's opinion they lead so irresistibly to the conclusion that there have been two periods of dike formation in the Adirondacks, quite widely separate in point of time, that it is deemed wise to publish the evidence even though at present it falls short of absolute demonstration.

Present Rock Classification.

Kemp has recently published the following scheme of classification for the rocks of the eastern Adirondacks,* as the best that can be done with our present knowledge of the district. With the exception here discussed, the writer fully agrees with his generalization.

The series is as follows, commencing at the bottom:

I. "A gneiss series, usually laminated, but at times quite massive. The gneisses almost always contain quartz. The

*J. F. Kemp, Rep. N. Y. State Geol.., 1893, Vol. I., p. 144.

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dark silicate is variable and frequently lacking. The orthoclase is almost invariably microperthitic. The rocks of this series contain the workable iron ores."

II. "A series of crystalline limestones and ophicalcites, black hornblende-pyroxenic schists and thinly laminated garnetiferous gneisses."

III. "A series of rocks of the gabbro family, ranging from pure aggregates of labradorite through varieties with increasing amounts of dark silicates to basic olivine gabbros. The rocks of this series contain the titaniferous iron ores."

IV. "A series of Palæozoic sedimentary rocks, whose oldest member is the Potsdam sandstone and whose latest member thus far identified is the Utica slate."

V. "A subordinate series of igneous rocks that now form dikes, and one notable laccolite, and that are later than the Utica slate. These consist of "trachyte" (bostonite) and of basic dikes, mostly diabase."

Proposed Change in the Classification.

The contention of this paper is that there should be inserted between III. and IV. of the above classification a sub-division, as follows:

A subordinate series of igneous rocks that now form dikes, that followed after the dynamic metamorphism of the first three series and antedated the beginning of deposition of series IV., and that in their typical development consist of diabase.

And furthermore, that from the description of series V. the word diabase be stricken out, and that the last sentence of this description be made to read that these consist of "trachyte" (bostonite), and of basic dikes, mostly camptonites and monchiquites.

The Dikes.

Description.—The various rock species which the dikes furnish have been recently so fully described by Kemp and Marsters* that any extended description of them here seems superfluous. A group of acidic dikes of trachytic habit occurs to which the name bostonite has been applied. By far the greater number of the dikes are quite basic, and are called diabases, camptonites, monchiquites or fourchites, according to variations in mineral content and in structure.

Distribution.—Perhaps the earliest impression to be gained concerning the distribution of the dikes is that they are found more frequently cutting the Pre-Cambrian series than the Pa-

* Bull. U. S. Geol. Surv.

Transactions N. Y. Acad. Sci., Vol. XV., Sig. 17, Sept. 25, 1896.

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læozoic rocks. During a portion of the past three summers the writer has been at work in Clinton county, and has completed a preliminary survey of the county and studied some parts in great detail. During the progress of the work 102 dikes have been mapped, and these can constitute but a small proportion of those which really exist. In addition to these, 12 dikes have been described from the county by Kemp*, and two by Eakle†, which the writer has not seen, making a total of 116 dikes known in the county. Out of this large number only five cut the Palæozoic rocks, yet these latter form the surface rocks over more than half the county ,and moreover the half in which the exposures are easily accessible and in which the detailed work has been done. It should be noted that this discrepancy is by no means as marked in Essex county, just to the south, for more dikes are recorded there cutting the Palæozic series and the proportionate amount of territory underlaid by that series is vastly less.

Distribution.—When the dikes are studied and classified another fact is brought out. Of the 116 dikes known in Clinton county, 11 are bostonites, 2 camptonites, 3 monchiquites, and the remaining 100 are diabases, though these latter vary toward the camptonites and monchiquites, and some of them show abnormal features. The diabase dikes far outnumber all the rest, *and are confined to the Pre-Cambrian rocks.* A tabulation of the dikes described by Kemp from Essex county, and from the Vermont shore of Lake Champlain, brings out the same features.‡ 58 dikes are noted from Essex county, of which 48 are diabases, all of which cut the Pre-Cambrian rocks. 45 dikes are recorded from the Vermont shore, all in Palæozic rocks, and of these but one has been recorded as being of diabase.§ This latter is of especial interest as being the only recorded instance in the district of a dike of well-marked diabase cutting rocks more recent than the gabbo. The bostonites are found cutting everything from the gneiss of series I. to the Utica slate at the summit of series V.

The distribution of the more basic dikes is puzzling. Of the non-feldspathic fourchite-monchiquite series but a single dike is known in the Pre-Cambrian rocks, viz., the dike of fourchite found by Kemp in the gabbro of Bouquet mountain, Essex county. But the total number of these dikes known from the New York side of the lake is not large, all those described by Kemp, with the exception above noted, being found in Vermont.

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*J. F. Kemp. Bull. 107. U. S. Geol. Surv.

†A. S. Eakle. Am. Geol.. July, 1893. pp. 31-36.

‡ Bull. 107. U. S. Geol. Surv., pp. 54-59. Those described since the appearance of the bulletin merely increase the number of diabase dikes.

§ Bull. 107. U. S. Geol. Surv. p. 48.

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The typical camptonites are apparently confined to the Palæozoic rocks. This peculiarity of distribution, coupled with the close agreement in chemical composition between the diabases and the camptonite sand with the fact that they seem to grade into one another lead Kemp to the idea that the difference between the two were due mainly to variations in the physical conditions under which solidification took place.* Under the circumstances it becomes a difficult matter to decide whether any of the Pre-Cambrian, camptonite-like diabases should be classed with these later camptonites or not. We certainly should expect to find them, or their representatives, in the earlier rocks, unless we accept the notion that the diabases in toto are their representatives, thus precluding two periods of dike formation.

Not only are the diabase dikes more abundant, but they are far more widespread than the others. As work is pushed westward into the Adirondacks, they are everywhere found. The other dikes seem however to have had their main centre of activity in western Vermont, and to decrease rapidly in number going north and west.

Their Scarcity north of the Adirondacks.—In order to fully demonstrate the existence of a Pre-Cambrian period of dike formation in the region under discussion, it will be necessary to find dikes which are cut off by the Potsdam sandstone, such as have been recently described by Smyth† from the Thousand Islands. Such a case has not yet been met with. During the past field season the writer mapped the Potsdam—Pre-Cambrian boundary from Lake Champlain west to the Franklin county line, along the northern edge of the Adirondacks. Along the entire distance no actual contact between the two rock series was seen, though in several instances gneiss or gabbro and coarse basal conglomerates were found within a few feet of one another. Though in this respect the work was disappointing, it was during its progress that the idea of two periods of dike formation changed from a working hypothesis into a matter of conviction. The boundary here has a very different character from that along Lake Champlain. From the outlying gneissic ridges a high level plain slopes away toward the St. Lawrence valley, occupying all the northern part of Clinton and Franklin counties and a great area in Canada, with nearly horizontal Potsdam sandstone as the surface rock throughout, and with coarse basal conglomerates invariably appearing in force as the contact is approched. Along the lake on the contrary there is a much faulted strip, the descent to which from the outlying ridges of

* Bull. 107. U. S. Geol. Surv. p. 27.
† C. H. Smyth, Jr., Trans. N. Y. Acad. Sci. Vol. XIII., pp. 209–214.

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the older rocks is in the main quite abrupt; in which within short distances the Potsdam may be found in patches at heights varying from the lake level (101′ A. T.) to 1500′; in which it is not always the Potsdam that is in contact with the older rocks; in which basal conglomerates are infrequent, and in which a large number of the contacts are unquestionably due to faulting; in which therefore decisive evidence as to the age of the dikes would not be likely to be forthcoming. But the evidence on the north is most important.

All along the northern contact line dikes are of frequent occurrence in the older rocks, and as abundant close to the contact as away from it. In the wide expanse of Potsdam country north of the contact *not a single dike has been noted*, though a careful watch was kept for them, and exposures are frequent and often of great areal extent, as in the Flat Rock district, in Altona township. In the absence of any specific case of a cut-off, this evidence seems very strongly to point to the pre-Potsdam age of the dikes in the older rocks.

SUMMARY.

A pre-Cambrian as well as a post-Ordovician period of dike formation in the Adirondacks and along Lake Champlain is rendered probable because of (1) the much larger number of dikes occurring in the pre-Cambrian rocks; (2) the fact that the great proportion of the dikes so occurring are of diabase, while diabase dikes are not found outside of the pre-Cambrian areas, and have a much wider distribution than the other dikes which do so occur; (3) the fact that along the line of contact of the Potsdam with the older rocks north of the Adirondacks the quite plentiful diabase dikes in the older rocks are apparently cut off by the Potsdam.

WESTERN RESERVE UNIVERSITY,
March 25, 1896.

THE STRATIGRAPHICAL RELATIONS OF THE BROWN'S PARK BEDS OF UTAH.

BY JOHN DUER IRVING, A. B.

(Read May 18, 1896.)

Until a comparatively recent date the science of vertebrate palæontology was based largely on the study of fossils obtained from European and other foreign localities. Between 1871 and

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1873, however, the investigations begun by Leidy, Marsh and Cope in the Tertiary lake basins, which form so prominent a feature in the geology of the western interior, revealed the presence of vertebrate fossils on the American continent. A further study of these fossils showed them to be of great scientific value, and many palæontologists turned their attention to their collection and study. This gave a great impetus to the science of vertebrate palæontology, and led to the discoveries of Cope, Marsh, Osborn, Scott, Wortman and many others, at the same time resulting in a thorough and exhaustive study of the faunal relations and geology of the various members of the western Tertiary. The White River Miocene of South Dakota, the John Day beds of Oregon, the Deep River beds of Montana, the Bridger and Washakie basins of southern Wyoming, the Uintah beds of Utah—all these were thoroughly searched and explored by the fossil gatherers. No Tertiary was left unexplored, and palæontologists were eager to find fresh fields for discovery. It was thus natural that their attention should be attracted by a series of shales situated in northern Utah, at the eastern extremity of the Uintah Mountains, a formation that had been for a long time known to geologists, but one which they had not as yet been able to identify. I refer to the beds known under the name of Brown's Park. A thorough search of these beds was then made, for it was thought that, as they were of an entirely different nature from any Tertiary in the region, such vertebrate remains as might be there discovered would prove to be of great scientific value.

The result was—and it is this fact perhaps that has been the cause of the many conflicting opinions concerning the beds—that as a source of vertebrate fossils the Brown's Park was an absolute failure. The formation is throughout entirely barren. Not only have the bones of mammals not yet been discovered, but, with the exception of a few mollusca, not even an invertebrate.

As a geological question, however, in proportion as their barrenness has become more evident, the interest in the beds has increased, and it is the purpose of this paper to set forth a few of the more important facts connected with them.

Geographically considered the formation is situated in northeastern Utah at the eastern extremity of the Uintah Mountains. The Green River which is the great drainage factor of this part of the country flows south through southern Wyoming, cuts into the edge of the Uintah fold and takes a sharp bend to the east. It pursues this easterly course for some 50 miles, and finally sweeps around to the south again, crosses the axis of the

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Uintahs and emerges into the low lands of the Uintah Valley. It is a valley along the eastern portion of this bend in Green River that has received the name of Brown's Park. (See Plate XVIII.)

Along the axis of the Uintah Mountains, which have a nearly east and west tend, is exposed the hard, metamorphosed sandstone, known as the Weber quartzite or Uintah sandstone. At the eastern extremity of the range this exposure divides, sending out two long, eastwardly projecting spurs, one of which passes along the northern, the other along the southern border of Brown's Park valley. Of these the southern is by far the broadest and forms the real axis of the range, while it is at the same time much the longer of the two. We have thus a roughly outlined valley somewhat resembling the letter U, tilted on one side with its open end towards the east and the upper arm somewhat shorter than the lower.

Across the open end of the U runs the low divide that separates the drainage areas of the Green and Little Snake rivers, while between this divide and the upper, shorter arm flows Vermilion Creek, a stream which must have played no inconsiderable part as a silt bearer in the formation of the Brown's Park beds.

To the north of the mountains lie the Bridger and Washakie basins, where the entire series of Eocene tertiaries are exposed, but most noticeably the beds of the Bridger epoch. These two basins are drained, the one by the Green river and the other by Vermilion creek and it seems probable that these formations furnished much of the material of which the beds in Brown's Park are composed.

The last named beds themselves come in contact with two formations in the valley and perhaps a third at the open end.

The first is the Weber quartzite before mentioned and it is directly against the eroded flanks of this hard rock that the Brown's Park is seen to rest.

The second is a narrow strip of Green river shales which sweeps around the upper arm of the valley and runs along its northern edge, forming what is known as O-wi-yu-puts Plateau. These shales dip to the south from 18° to 25° and can be seen passing unconformably under the Brown's Park.

The third formation is perhaps a portion of the Green river shales or it may be another and later tertiary. It forms the divide between the drainage areas of Little Snake river and Vermilion creek, which we shall for convenience call the Snake river divide. This divide is, however, so covered by accumulations of soil that the true relations of the beds within the park

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and those to the southeast could not be made out. It has been supposed by some geologists that the Brown's Park group saddled across this divide and extended far to the southeast, but the different lithological character of the beds there exposed, as well as their resemblance to the Green river shales, seems to invalidate such a theory.

Lithological Characters.—The lithological characteristics of the Brown's Park are exceedingly peculiar and are entirely different from those of any other tertiary in the region. The most characteristic strata are composed of a very soft, friable, silicious silt, everywhere thinly bedded and throughout highly calcareous. They differ entirely from those of the Bridger group to the north of the mountains and the Uintah to the south, in containing comparatively little clay and being everywhere very soft. The Bridger is characterized by a grayish or greenish tinge and the Uintah by a prevailing brownish-red color, whilst the Brown's Park is always white. The most important difference, however, is in the texture.

All the Eocene formations in the Green River Basin contain, besides their softer strata, seams of a hard compact sandstone of either a deep green, brown or yellow color. These seams never appear in any part of the Brown's Park beds. The latter are everywhere the same, soft, friable mass which crumbles easily in the fingers and offers almost no resistance to erosion. For so soft a formation, indeed, the beds are eroded surprisingly little, and one is tempted to wonder, on entering the park, how beds of such a nature could have withstood the degrading forces of nature for so long a time. Beds of conglomerate also occur, but these are confined to the edges of the valley, and since they are composed almost wholly of quartzite pebbles were obviously derived from the surrounding cliffs of Weber quartzite.

Geological Age.—In regard to the geological age of the beds great difference of opinion has prevailed. King, in studying them, did not venture to assign them to any age. He remarks:* "The area enclosed between Vermilion Bluffs, Brown's Peak, the Escalante Hills and Snake River is one in which the relations of the Tertiary are involved in much obscurity. It is a region which has suffered extensive faults and extraordinary erosion and is for the most part largely covered by deep accumulations of soil. It is certain that at some point in Vermilion Bluffs the Green River strata occupy the surface, and we are unable to observe any break, from Vermilion Bluffs southeastward into Brown's Park. The rocks in Brown Park are also in great measure covered by local accumulations of soil. Through-

* U. S. Geological Exploration of the Fortieth Parallel, page 384.

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out the southern part of the valley, wherever exposed, the Tertiaries are seen to be approximately horizontal and to be composed of soft friable beds. Along the north wall of the valley, however, there is a sharp break and the Tertiary rocks which come to the surface lie immediately against the quartzitic sandstones of the plateau and dip to the south at an angle of 25°. They are of a rather coarse, gritty character, containing many pebbles, and are prevailingly calcareous. They are unlike any Tertiary in the region; but from their calcareous nature, the fact of their being upturned at so high an angle, and their apparent connection with the series which sweeps around the eastern end of O-wi zu-kuts Plateau, they are assigned by Mr. Emmons to the Green River age. There seems to be a decided difference between the strata which are seen uptilted along the base of O-wi-zu-kuts Plateau and the soft, white, friable, horizontal beds of the valley itself, which are seen to extend eastward well towards the divide, separating the valley of Vermilion Creek from that of Little Snake River. It is not improbable that there are two distinct members here—the Green River, which is seen inclined along the northern edge of the park, and a more recent horizontal member assigned to a special group by Powell and which overlies the beds we have referred to the Green River age.

S. F. Emmons* classed the whole series as Green River shales, but he seems to be more uncertain than King as to their real geological horizon, for he says: "There is a possibility also that the upper beds of Brown's Park, which have been colored as Green River Eocene on the map, may prove, on further investigation, to be of Pliocene age."

He further states in a foot-note: "Since the above was written it has been reported that fossils of a Pliocene type have been found in the Tertiary beds of Brown Park."

Charles A. White,† who has most recently studied this region, regarded the whole series as equivalent to the Uintah or latest Eocene beds which are exposed to the south of the mountains. He further colors the beds on the map accompanying his report as extending far to the southeast along the Yampah River. He has, however, advanced no facts to support his theory concerning their age and seems to be somewhat undecided in the matter. I will quote what he has to say on the subject:‡ "The Tertiary strata of this district are divided into four groups. The three lower ones are usually referred to the Eocene

* U. S. Geological Exploration of the Fortieth Parallel. Vol. II., p. 205.
† U. S. Geological Exploration of Fortieth Parallel, Vol. II., page 224.
‡ U. S. Geological Survey. Ninth Annual Report, page 690.

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without hesitation, while the upper (meaning the Brown's Park) is sometimes referred to the Eocene, sometimes to the Miocene and sometimes to the Pliocene." "The Brown's Park group is regarded as equivalent to the Uintah group of King. The latter name was given by King to those strata of the group that occur on the south side of the eastern end of the Uintah Range; but he did not recognize those upon the north and east as being different from the Green River group.* He then describes the beds and notes their non-conformity with those formations with which they come in contact. This is all he has to say concerning them. He does not say why he has classed them as Uintah.

In the face of so many conflicting opinions, it has been difficult to arrive at any conclusion as to the true geological age of the Brown's Park, and it was partly with a view to obtaining some fossils that would definitely settle the question that a party from the American Museum of Natural History entered the park during the past summer. A week's diligent search, however, failed to reveal the presence of a single fossil, vertebrate or invertebrate, with the exception of a few small fragments of bone that were not large enough for identification. These fragments were, nevertheless, carefully examined by Dr. Wortman, of the Museum, and he is of the opinion that from the condition of the bone it could not have been deposited earlier than the Pliocene or at most the Loup Fork Miocene. This coincides with the views of King and Emmons which I have quoted, and certainly seems to invalidate the supposition of White that the beds are of Eocene age.

Regarding the southeastern extension of the beds, it is to be observed that the relations of the portion included in Brown's Park Valley and that to the southeast of the Snake River divide are much obscured by local accumulations of soil. It seems, however, probable, as has been already observed, that we have here two distinct formations: one composed of the white silicious beds, which occur in Brown's Park, and are apparently of a much later age than any Tertiary heretofore observed in the Green River Basin; the other comprising the more coarsely bedded and darker shales to the southeast. The latter so strongly resemble the Green River Shales that they were not differentiated by King nor Emmons, and it seems not improbable that they may belong to that group. This, however, is an open question, and until a closer study has been made than it was the writer's fortune to bestow upon it, any positive statement would be premature.

*Loc. Cit., page 691.

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The important points of this discussion may then be summed up as follows:

First. The formation in Brown's Park Valley is lithologically different from that to the southeast.

Second. The southeastern portion resembles the Green River Shales.

Third. The Brown's Park is softer and more friable than any Eocene Tertiary yet observed, and is surprisingly little eroded for even a Pliocene formation.

Fourth. The fragments of bone discovered were not deposited earlier than the Loup Fork Miocene.

From these facts it may be inferred that the beds in Brown's Park Valley represent a Pliocene Lake, which was included between two steep quartzitic cliffs and stretched east only as far as the Snake River divide.

Having assigned the beds to the Pliocene, the question naturally arises: How can we account for the presence of these beds —isolated in position and distinct in character from any Tertiary in the region—and yet lying directly along the course of the great drainage factor of the country, Green River? If they were deposited in a lake that did not exist until all the other Tertiary lakes had disappeared, how do we account for the appearance and later the subsidence of this Pliocene lake? The explanation lies in the peculiar physiographic position of the sediment. It lies, as previously stated, in the U-shaped valley formed by the two eastwardly projecting spurs of Weber quartzite that form the inceptive portion of Uintah fold. The Green River cuts into the fold at Horseshoe Cañon, some 30 miles to the west of the valley, flows east in a deep cañon along the edge of the quartzite and emerges into the park at the vertex of the U. Thence it runs along the low valley for some twenty miles only to sweep around to the south and again enter the quartzite by the Cañon of Lodore, one of the boldest and deepest cañons of the Rockies.

It is a fact no longer disputed that these deep cañons in the quartzite by which the river crosses the mountains were first established in the softer overlying formations and that these formations furnished much of the corrasive material by means of which the harder rocks were cut away. As long as the river had only these soft rocks to deal with, the forces of erosion and elevation balanced each other, and the bed of Lodore Cañon remained upon the same level as the bottom of the valley. But somewhere near the close of the Miocene the forces no longer balanced each other. The greater resistance of the hard crystalline quartzite, combined with the gradual elevation, prevailed

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over the erosion; and the bottom of Lodore, which formed the only outlet to the park, rose many feet above the valley, banking up the waters of the river into a lake.

Slowly this lake increased in size and stretched out over the valley of Brown's Park until the gradual cessation of those orogenic movements that elevated the Uintah range again threw the balance on the side of erosion, causing the lake as slowly to subside and disappear. It may at first seem strange that a similar damming of the river did not take place at Horseshoe Cañon where the Green River enters the fold; but an explanation of this lies in the relative position of the two cañons. That by which the river enters the park lies on the edge of the fold; its exit, on the other hand, cuts directly through the axis of the mountain. It is evident at a glance that the point where the river first began to cut into the quartzite was in this axis, *i. e.*, in the point of earliest elevation. Therefore the erosion in the long cañon on the edge of the fold would have had only the uppermost and least crystalline strata to deal with when Lodore had already penetrated far within the hard, metamorphosed core of the formation.

It is here that the importance of our observations concerning the dip of the beds in the valley becomes apparent. The perfect horizontality of the Brown's Park beds throughout their entire extent shows that it was not until the elevation had ceased that Lodore was again cut down to its old level and the waters of the lake allowed to escape.

The sharp dip to the south of the exposures of Green River Shales on the northern edge of the park, on the other hand, shows that they were involved in the fold and that the elevation must have continued long after the Green River Lake had become a thing of the past.

COLUMBIA COLLEGE, May, 1896.

EXPLANATION OF PLATE.

Plate XVIII. Geological Maps of the Region about Brown's Park, Utah. The geography is based on the map by C. A. White, in the Ninth Annual Report of the Director of the U. S. Geological Survey.

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THE GENETIC RELATIONS OF CERTAIN MINERALS OF NORTHERN NEW YORK.

By C. H. Smyth, Jr.

To mineralogists few locality names are more familiar than those of the northwestern portion of the Adirondack area of crystalline rocks, comprising parts of St. Lawrence, Jefferson and Lewis counties, N. Y. Every large collection contains numerous specimens representing these localities; while their importance is further demonstrated by abundant descriptions, analyses and figures in mineralogical text-books and in various journals. In this literature much information is given as to the crystallographic, physical and chemical characteristics of the different minerals; but little has been published as to their origin and associations. The present paper is concerned with this latter phase of the subject, being, however, only a brief consideration of a few special cases, rather than a comprehensive survey of the entire field. It is hoped that future study may afford the basis for a more extended account of the mineral occurrences, with their classification upon a genetic basis; but at present the available data are insufficient for this purpose.

It seems rather surprising that this line of investigation has not been previously followed up, as the minerals have been so long and so widely known. But the same might be said of many other localities, and is to be explained by the fact that mineralogists so generally confine their studies to the laboratory, while geologists devote their attention chiefly to minerals of petrologic or economic importance. Perhaps, however, the most potent cause for the neglect of this field lies in the fact that in so many cases the data obtainable are insufficient to afford a satisfactory explanation of the origin of the minerals. As a result of these combined causes, many occurrences remain unstudied that might shed much light upon the questions of mineral association and genesis.

The localities here considered belong to a class interesting to geologists and mineralogists alike, as they are important in shedding light upon some phases of the geological history of the region, while, at the same time, they afford a rich field for mineralogical study.

It is only necessary to read Dana's list of the mineral localities of the region to find a suggestion of some of the laws of association as well as a clue to possible origin. Galena, pyrite and, less often, sphalerite, commonly occur together in a gangue of calcite and other carbonates, pointing clearly to some kind of

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vein formation. The large masses of hematite with minor carbonates, quartz, millerite, etc., are suggestive of extensive metasomatic action. The widely diffused phlogophite, graphite, tremolite, etc., in the crystalline limestone are evidently a product of regional metamorphism. The beautiful tourmaline, with associated quartz, pyroxene and other silicates, may, with some probability, be referred to fumarole action. But perhaps the most striking association is that found at many localities, and involving all or several of the following minerals: pyroxene, scapolite, phlogopite, titanite, amphibole, orthoclase, albite, wollastonite, graphite, zircon. Of these, the first five are apparently most common. For such an association as this, contact metamorphism at once suggests itself as a probable cause.

But while conclusions drawn from a mere statement of the simultaneous occurrence of species have a certain value as indicating lines of investigation, they can not, of course, be regarded as anything but tentative until tested by field study. And, as a matter of fact, while the field relations of some localities prove to be precisely what might be predicted from a knowledge of the occurring minerals, in other cases the relations are of a doubtful or even contradictory nature. It is hoped that the study of typical and clearly-defined instances of the different classes of mineral occurrences may furnish data for the interpretation of the more uncertain cases, and for, at least, a partial formulation of the laws of association as related to origin. For the present, the discussion will be limited to the last group of minerals referred to above, dealing first with a few typical examples and then taking up some of the doubtful cases.

The chief locality in question is mentioned in Dana's list, being on the Martin farm in Rossie, some two miles north of the village. Blasting has been done here, so that the minerals are well shown, forming an irregular mass several yards in diameter. The prevailing minerals are pyroxene, phlogopite, scapolite, calcite and titanite, with minor apatite, tourmaline and quartz. The pyroxene is in large crystals, two or three inches in diameter, of a dark green or black color. The scapolite is also in large crystals, with prisms of first and second orders about equally developed. The color is generally gray. The composition is probably near that of wernerite. The mica is in large, irregular masses of a very dark brown or black color. The tourmaline is black, and in small crystals not very abundant. The titanite, in very small crystals of a rich cinnamon brown color, is mostly deposited upon the other minerals, with the exception of the coarse calcite which encloses and fills the cracks between all of the others.

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As stated above, this is a grouping of minerals that might be regarded as probably of contact origin. At first sight, the form of the mineral deposit seems opposed to this explanation, but the objection disappears upon closer examination. For while the deposit is an irregular mass, rather than a clearly-defined band or zone, it is found to be continuous with such a zone, of which it is a local expansion. When the surrounding rocks are examined the mineral deposit and the zone of which it is part are found to lie between crystalline limestone and a rock of totally different character, which, at some points, would be called a gneiss, while, at others, it has more the aspect of a massive rock, though the gneissoid structure is seldom entirely lacking.

The occurrence of the minerals upon such a contact, when taken in conjunction with their nature, is highly suggestive of their formation by contact metamorphism; and that such is actually the case is thoroughly demonstrated both by the structural relations of the rocks in the field and by the character of the gneissoid rock as revealed by the microscope. This rock forms rather thin sheets or beds in the limestone, presenting much the aspect of interstratified layers; and this, with the gneissoid character, at first leads to the idea that the rock is a metamorphosed sediment. But when the sheets are traced along the strike they are found to cut across and break through the limestone in such a way that they must be regarded as intrusive. This is an important point bearing upon other occurrences of a similar nature where the true relations are less clearly exhibited.

Thin sections of the gneissoid rock entirely substantiate the conclusion that it is of igneous origin. It consists of hornblende, biotite and plagioclase, with considerable titanite, some apatite and occasional grains of garnet. The hornblende sometimes contains a little colorless pyroxene, evidently all that is left of larger amounts of the mineral that have changed to hornblende. This fact, coupled with other cases in the region, suggests that the rock may have been originally a gabbro; but there is no proof that such was the case, and it must be classed as a hornblende-mica diorite. The grain and structure vary considerably, the finer varieties resembling in structure the "granulitic" gneisses, while the coarser have a typical igneous structure. In these the plagioclase is slightly older than the ferro-magnesium minerals, so that it shows a rough approximation to lath-shaped individuals, while the hornblende and mica have irregular outlines, somewhat conditioned by the plagioclase. There is a strong resemblance to the gabbroitic structure figured by Rosenbusch.

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The mineral composition and structure of the rock revealed by the microscope would be sufficient to establish its igneous nature in the absence of all supporting field evidence. As it is, the proof is complete. This leads at once to the conclusion that the minerals of this locality have been formed by contact metamorphism, where an intrusive rock of intermediate composition breaks through a limestone. All of the phenomena are so clearly exhibited that it seems impossible to arrive at any other conclusion, and the locality is, for this reason, of much importance as a standard of comparison. At the same time, the bedded aspect of the intrusive, its gneissoid character, and the great variation in the width of the contact zone, all point out lines along which the phenomena might be so modified as to introduce much obscurity in the relations of mineral occurrences of like origin.

The last mentioned point, in particular, needs further consideration. As stated above, the mineral body is part of a zone which follows the contact of the diorite and limestone. But through most of its extent this zone is very narrow, ranging from a few inches down to almost complete disappearance, and consisting of a fine coccolitic mass, instead of the large crystals of the main body. To account for such wide variation in the amount of mineral development, it seems necessary that there should be corresponding variation in the rocks involved, or in some other factor in the process. The first proposition can not be admitted, as both the diorite and the limestone are entirely too homogeneous to allow the required amount of variation. The alternative raises the question as to how much of the contact action is due to heat alone, and how much to the effects of heated solutions and gases. This question seems to be quite definitely answered by the phenomena of occurrence already described. The narrow band of coccolitic material which marks the whole contact may well be the result of heat acting upon the limestone, accompanied by a slight transfusion of material from the diorite, but without the intervention, to any great extent, of other agents. But it is very difficult to account for the sudden expansion of the belt into a large mass of finely developed minerals, unless it has resulted from a concentration, at this point, of heated solutions rich in mineralizing agents.

As to the cause of this concentration, it is impossible to come any closer than to say that, doubtless, there was here a line of minor resistance which afforded a channel for the transmission of the solutions. That the mineral mass could not result from the rearrangement of materials in the limestone is apparent from an examination of the latter rock. It is a fairly pure mass of

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carbonate of lime, probably with considerable magnesia. The minerals, on the other hand, are chiefly silicates of lime, magnesia, iron and alumina, while there are also present titanium, phosphorus, boron, etc., in less amounts. The coarse calcite is clearly a product of recrystallization and the structure of the mass is totally different from that of the limestone. It is evident that the minerals must be a product of the commingling of material derived from depth with the constituents of the limestone, not by fusion, but by the intervention of solutions. And yet, while it is impossible to avoid the conclusion that there has been this transfer or "migration" of material, the phenomena are quite in harmony with the view that such transfer is limited in extent. For its effects are conspicuous only at this one point on the contact, and even here the action is confined to an area of a few yards, while, as above stated, the contact zone as a rule is extremely narrow. Similar facts are exhibited at many other points in the region.

Nevertheless, in other cases, as will appear later, there seems to have been a migration of material to considerable distances, although even then the mineral deposits are quite clearly defined. No fixed rule appears to exist, and instances of the latter kind find their opposite in cases where the limestone is unchanged. But when the latter is true the intrusive rock itself is commonly modified near the contact, very often carrying a large amount of titanite. An example of this is shown by a granite a short distance south of the locality under consideration. Two probable causes for this limited change suggest themselves: the purity of the limestone, and the fact that it is highly crystalline throughout. These two conditions require the addition of foreign material, together with the heat, in order that any marked effects should result.

The process suggested has much in common with fumarole action, and it can hardly be fortuitous that, together with typical contact minerals, there is associated the common fumarole product tourmaline. The same association appears elsewhere in the region, and, as a matter of fact, it is difficult to distinguish clearly between contact and fumarole action. It seems, then, justifiable to go a step further in tracing the genesis of the minerals under consideration, and to conclude that not only are they contact products, but that heated solutions and gases have been of prime importance in their formation.

Summarizing briefly the phenomena exhibited in this locality and bearing upon the problems of mineral genesis and association: Pyroxene, scapolite, phlogopite, mica, apatite, titanite, quartz, tourmaline and coarse calcite have been formed as con-

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tact products, where diorite breaks through crystalline limestone. Heated solutions and gases have been the immediate agents of mineral growth, and their action has been so concentrated that the minerals have, for the most part, developed in a large mass, instead of an extended zone.

Similar phenomena are shown at a point a few rods south of the locality above described, but with some considerable variations. The same minerals occur, with apatite and pyroxene decidedly predominant, the former species in particular appearing in quantity, while at the first locality it is quite inconspicuous. The minerals form a coating upon a nearly vertical wall thirty to forty feet long and about twelve feet high. This large surface is so completely covered with interlocking crystals of the various minerals that the rock composing the wall is entirely concealed from view. Apatite and pyroxene in crystals sometimes reaching a length of six inches are, as already stated, the conspicuous species shown, feldspar, scapolite, phlogopite and titanite being less abundant. The rock upon which the minerals are supported is of a dark gray color and has the appearance of a gneiss or a plutonic rock. The material which has split off so as to expose the face with the minerals is a crystalline limestone. The structural relations of these two rocks are precisely the same as those shown by the diorite and limestone of the first locality, and there can be no doubt that they result from the intrusion of the gray rock into the limestone. Sections of the gray rock do not, as in the previous case, give positive evidence in support of this view; neither, on the other hand, do they offer anything against it. The rock is a granular aggregate of feldspar with bright green pyroxene, a little hornblende (probably secondary), some biotite and considerable titanite. The feldspar is, in most sections, largely twinned, but some untwinned grains are always present and occasionally they become most abundant. Thus the rock might be classed, so far as this evidence goes, as a rather acid gabbro, or perhaps as a member of the intermediate group of monzonites. So far as structure is concerned, it might be either an igneous rock or one of the pyroxene gneisses of doubtful origin. But the field evidence is sufficient to establish its igneous nature, while its structure is closely analogous to parts of the Russell gabbro recently described by the writer,* and it is not improbable that further investigation might show the rock to be of this nature. But for present purposes it is sufficient to know that it is intrusive, for this establishes clearly the origin of the second group of minerals. It is another instance of contact action; and while the

*Am. Jour. Sci. (4) I., p. 273.

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production of minerals is not confined so closely to a limited area, still the well-developed crystals are limited to a small part of the contact zone, and there can be no doubt that their formation was largely dependent upon the presence of heated solutions and gases. The abundance of apatite is in harmony with this conclusion, this mineral being so often a product of pneumatolytic action.

In both cases described, the large size and perfection of the crystals may result in part from the influence of mineralizers, as suggested by Williams* for pegmatites, and in part from a slow growth. The influence of mineralizers can hardly be questioned, while a rather slow crystallization is also probable. At the time of intrusion the surrounding rocks would be quickly heated, and the normal contact zone would develop as a result. But heated solutions would continue to circulate during the entire period of slow cooling, and along the lines of ready transmission the limestone would gradually give place to new minerals. Such conditions would, judging from experimental data, be favorable to the growth of large crystals.

Before passing from these clearly defined cases of the formation of important mineral masses by contact metamorphism to more doubtful and obscure occurrences, brief mention may be made of previously described localities.† The well-known minerals of Natural Bridge are, for the most part, on the contact between limestone and an intrusive rock of variable composition, which, in the absence of careful investigation, has been tentatively called gabbro. The minerals of these contacts are pyroxene, orthoclase, mica, scapolite, wollastonite, titanite, zircon and calcite. This is an association quite similar to that of the Rossie localities, though lacking apatite and tourmaline, and having instead wollastonite and zircon. The contact nature of the masses is perfectly clear and the same concentration of mineral development at certain points is well shown.

In the localities thus far described, the association of species is such as to suggest at the outset their formation by contact metamorphism; and in the foregoing pages the effort has been made to show that this is actually the case. The data derived from these clearly-defined instances afford a basis for the consideration of occurrences where the phenomena actually shown render a direct determination of origin impossible. The analogy is sometimes so complete that conclusions

*G. H. Williams, General Relations of the Granite Rocks in the Middle Atlantic Piedmont Plateau. XV. Ann. Rept. U. S. G. S., p. 684.

† C. H. Smyth, Jr., The Crystalline Limestones and Associated Rocks of the N. W. Adirondack Region. Bull. Geol. Soc. Am. VI., p. 279.

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drawn from it may be regarded as extremely probable, while in other cases much doubt remains.

The well-known black tourmaline locality of Pierrepont affords an instance of this kind. The tourmaline, with associated pyroxene, phlogopite, quartz and calcite, occurs in irregular masses in crystalline limestone. These masses are scattered and clearly not upon any line of contact. Nevertheless, the gneissoid rock which appears at the other localities is represented here, appearing a few rods to the north. It is a dark, basic looking rock ranging from distinctly gneissoid to fairly massive. It cannot be traced without break to the limestone, but where it should come in contact with the latter a much finer rock of a dark color appears. This fact is important, for if the gneiss is intrusive its marginal portion would naturally be finer. Sections of the gneiss show it to be made up of plagioclase and pyroxene, both monoclinic and orthorhombic, together with garnet and various accessories and alteration products. It has every appearance of being a somewhat metamorphosed gabbro. It can hardly be a mere coincidence that the minerals appear in the limestone just where it approaches this rock, and the conclusion that they have been formed by solutions set in circulation by the intrusion of gabbro must be regarded as extremely probable. That tourmaline is usually formed in connection with acid rocks might be urged in contravention of this conclusion (and Lacroix* regards the occurrence as a granite fumarole); but that this is not necessarily the case is shown by the first Rossie locality where tourmaline, like that of Pierrepont, is formed on the contact zone of a diorite or gabbro. The two cases are, indeed, closely similar, the only marked difference being that at the first locality the solutions worked along the exact contact, while at the second they traversed the limestone at some distance from the intrusion. The first case would be considered contact metamorphism in the strict sense of the term; the second might be regarded as fumarole action; but between the two it is hardly possible to draw any very definite line. In both cases it seems clear that heated solutions have done most of the work, and the exact locus of mineral growth, being determined by lines of least resistance to the transmission of solutions, must be dependent chiefly upon the character of the limestone.

The question as to how far such solutions may extend their action is pertinent in connection with the interesting locality on Moore's farm in Russell. Here the minerals are pyroxene (a

* A. Lacroix, Contributions a l'étude des Gneiss a Pyroxène et des Roches a Wernérite, p. 193.

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diopside variety in very large crystals), gray amphibole, feldspar, scapolite, phlogopite and tourmaline. The minerals fill irregular pockets or form short veins, scattered through impure crystalline limestone. The mode of occurrence is similar to that at the tourmaline locality, except that the minerals are more abundant. The association at once suggests a contact zone; but the limestone is the only rock shown in the immediate vicinity, there being nothing that could be regarded as an intrusive. Thus, there is afforded one of the localities of most doubtful nature, referred to at the outset of the inquiry. The minerals are precisely those species that might be expected in a contact zone, but no igneous rock is at hand to produce them. Were the occurrence an isolated one it would be most difficult to account for; and even with the knowledge gained from other localities it is only possible to suggest a hypothetical explanation, for which there is little positive basis. Recalling the phenomena shown at the first-described locality, together with the less decisive data of the Pierrepont tourmaline locality, it seems possible that the minerals under consideration may have been formed by the action of solutions connected with an intrusion that now underlies the locality without any exposure at the surface, or by one that extended as a sheet above the minerals and has now been removed by denudation.

That this explanation is based entirely upon analogy, using the laws of association as a guide, is evident, and its purely hypothetical character needs no further accentuation. But the locality is far from unique in this respect; indeed it may serve as a type of many localities where positive data as to the origin of the minerals are lacking, and it is possible to get a clue to the solution of the problem only by applying the laws derived from a study of more favorable localities.

An occurrence suggesting two very different explanations is on the farm of T. Fitzgerald in Pierrepont. This is another of the well-known localities at which much blasting has been done, and from which large quantities of minerals have been taken out. The association resembles that of the previously-described localities, but with fewer species, the minerals being pyroxene and scapolite, in large, coarse crystals, together with the peristerite variety of albite. Coarse pink calcite encloses the other minerals.

The mineral body occurs upon the contact between crystalline limestone and a rather fine, granulitic pyroxene gneiss. The gneiss forms a sheet that has the appearance of being interbedded, and there is some indication of a gradation between the two rocks; but in neither respect is the evidence entirely satis-

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factory. A quarter of a mile to the southwest another sheet of gneiss presents similar relations to the limestone, and here again the contact is marked by an extensive development of pyroxene and scapolite, although the mass has never been opened up. The general relations of these deposits are so like those shown by the typical cases of contact metamorphism that the conclusion is at once suggested that they have been formed by the same process. This supposition requires that the intrusive rock now represented by the gneiss should have undergone considerable modification; but this is so commonly the case with the igneous rocks of the region that no difficulties are presented. Nevertheless, while there is evidence in favor of the formation of the minerals by contact metamorphism, the case is an extremely doubtful one. Another explanation suggests itself as applicable and equally, if not more, probable. According to this, the minerals may result from the mingling of the silica, alumina, iron and alkalies of the gneiss with the lime and magnesia of the limestone, and the crystallization of the minerals during regional metamorphism. The mingling of materials might be original, resulting from the gradual change of one kind of sediment into another; or secondary, being produced by circulation of water during metamorphism. It is conceivable that, under such conditions, an association of minerals might be produced quite similar to those resulting from an intrusion, particularly if the regional metamorphism involved high temperatures. The apparent gradation between the gneiss and the limestone is certainly in harmony with this view. Lacroix,* who has described the locality, seems to incline to this explanation, though he finds reason for believing that the gneiss itself has been modified by a granite intrusion not exposed at the surface.

The Wells farm in Pierrepont affords another locality where the relations are similar to those last described. The minerals are amphibole, of a green-gray tint, pyroxene, oligoclase, and quartz. The first mentioned species occurs in perfect crystals and radiating aggregates of much beauty. Here, the minerals form irregular masses on the contact between limestone and a rather acid gneiss. The latter rock is of a type which, though somewhat obscure in character, is, for many reasons, regarded by the writer as of igneous origin. At this point it may well be the contact facies of a coarse porphyritic granite-gneiss exposed a few rods to the north. Between the gneiss and limestone there is not, as at the previous locality, any trace of gradation, although two bands of gneiss appear with the limestone lying between. This structure might result equally well

*Op. cit. p., 184.

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from interbedding or intrusion, but the latter explanation is strongly indicated both by the exposures themselves and by analogy with other localities. When this locality is compared with those where the minerals are clearly the product of contact metamorphism, decided differences appear. The light-gray amphibole is a new factor; the scapolite is absent, and the pyroxene is of a light-green color and, from its superficial properties, would be classed as diopside. The pyroxene of the other localities is, on the other hand, dark-green or black, and decidedly augitic in aspect. Whether or no such differences as these point to a decidedly different origin cannot, as yet, be positively stated, but on *a priori* grounds it seems very doubtful that they do. Variation in the character of the intrusive rock and of the limestone would certainly seem a sufficient cause; while some localities, as yet undeveloped, show an association and habit intermediate between the extremes described.

To sum up briefly the leading facts presented above: Pyroxene, phlogopite, scapolite, titanite and feldspar, together with apatite, tourmaline, wollastonite, quartz and zircon, often occur together, and in several instances they are clearly a product of contact metamorphism.

Generally the intrusive rock is of intermediate composition, while the rock which it cuts is limestone.

In all of these cases it seems clear that heated solutions and gases have been the immediate agents of mineral formation.

Several of the above-named minerals also occur with light-gray amphibole on the contact between gneiss and limestone, and while the evidence is not conclusive it is probable that they are formed in the same way. In other cases it is possible that minerals on gneiss-limestone contacts may be a product of regional metamorphism.

Finally, a similar association appears when there is no other rock than the limestone shown. For such occurrences it is only possible to infer their origin from their resemblance to more clearly defined examples.

In conclusion, it should, perhaps, be added that if there appears to be, in the foregoing pages, an attempt to exaggerate the importance of contact metamorphism as a source of minerals, it is simply due to the fact already stated, but possibly not sufficiently accentuated, that this paper aims to consider only the single class of mineral occurrences which are certainly, or possibly, of this type.

HAMILTON COLLEGE, CLINTON, N. Y., June, 1896.

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Minutes of the Meeting.

May 25th, 1896.

A meeting of the Philological sub-section of the Section of Anthropology, Psychology, and Philology of the New York Academy of Sciences was held in Hamilton Hall, Columbia University, on the evening of May 25th, 1896, at eight o'clock. Fifteen members of the Society were present and President J. J. Stevenson was in the chair.

The President called upon Prof. Franklin H. Giddings, as Chairman of the sub-section to preside at the meeting. The presentation of the communications by the members which had been announced for the session was immediately begun.

Prof. Thomas R. Price, of Columbia University, brought forward the results of certain investigations upon "The Tradition of the Case-Forms in Chaucer's Noun." Carefully collected statistics show that Chaucer in his syntax, uses the case-forms in the following order of frequency: (1) dat. sg., (2) nom. sg., (3) acc. sg., (4) dat. pl., (5) acc. pl., (6) nom. pl., (7) gen. sg., (8) gen. pl. And again with reference to the relative proportion of usage there is a difference between the Teutonic noun and the Romance noun. Statistics were presented to illustrate the ratio.

Prof. Laurence A. McLouth, of New York University, discussed, "Some of the Sources of Bürger's Lenore," basing his investigations mainly on studies of Bürger's letters and of the books that formed the chief part of his reading. No less than eight different sources were shown to be capable of being traced with fair certainty. Among these Shakespeare stood high upon the list.

Prof. Henry A. Todd, of Columbia University, treated "The Etymology of Italian *andare* and related Words." Various etymologies that had been suggested were examined, but the paper favored bringing the word into association with Lat. *indagare* "to investigate."

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Mr. D. L. Pettigrew was nominated for resident membership in the Society and referred to the Council. The meeting then adjourned.

A. V. WILLIAMS JACKSON,
Secretary of Section.

REGULAR BUSINESS MEETING.

June 1st, 1896.

The Academy met with President STEVENSON in the chair. There were eight persons present.

In the absence of Secretary J. F. Kemp, in the West, C. C. Trowbridge was appointed by the chair Secretary *pro tem.*

The minutes of the last regular business meeting were read and approved.

The acting Secretary then presented the name of Dr. David Lyman Pettigrew, for election as a resident member, the name having been approved in due manner by the Council.

On a motion, Dr. Pettigrew was elected a resident member of the Academy.

The committee on a set of resolutions in reference to the pending legislation by Congress, relating to vivisection in the District of Columbia, presented the resolutions.

On motion, the resolutions were adopted, subject to any slight alterations thought advisable by the committee.

The Academy then adjourned until October.

C. C. TROWBRIDGE,
Secretary pro tem.

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LIST OF MEMBERS

OF THE

NEW YORK ACADEMY OF SCIENCES.

1896.

HONORARY MEMBERS.

		Elected.
Agassiz, Prof. Alexander	Cambridge, Mass.	1887
Akerman, Prof. A. R.	Stockholm, Sweden	1876
Barrois, Prof. Charles	Lille, France	1889
Bunsen, Prof. Robert	Heidelberg, Baden	1876
Croll, Prof. James	Edinburgh, Scotland	1876
Dallinger, Rev. J. H.	London, England	1887
Dawkins, Prof. W. Boyd	Manchester, England	1876
Dawson, Sir William	Montreal, Canada	1876
Descloizeaux, Prof. A.	Paris, France	1876
Flower, Prof. W. H.	London, England	1887
Frankland, Prof. Edward	London, England	1879
Geikie, Sir Archibald	London, England	1876
Geinitz, Prof. Hans Bruno	Dresden, Saxony	1876
Gibbs, Dr. Wolcott	Newport, R. I.	1889
Goodale, Prof. George L.	Cambridge, Mass.	1889
Haeckel, Prof. Ernst	Jena, Germany	1894
Hall, Prof. Asaph	Washington, D. C.	1889
Hall, Prof. James	Albany, N. Y.	1852
Hartlaub, Dr. Carl T.	Bremen, Germany	1864
Hauer, Prof. Franz Ritter von	Vienna, Austria	1864
Hofmann, Prof. A. W.	Berlin, Prussia	1876
Hooker, Sir Joseph D.	London, England	1879
Hubrecht, Prof. A. O.	Utrecht, Holland	1896
Kelvin, Lord (elected as Sir Wm. Thomson)	London, England	1876
Kenngott, Prof. Adolph	Zurich, Switzerland	1864
Klein, Prof. Felix	Goettingen, Germany	1896
Koksoharow, Prof. Nicholas von	St. Petersburg, Russia	1879

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		Elected.
Lange, Prof. Victor von	Vienna, Austria	1876
Langley, Prof. S. P.	Washington, D. C.	1887
Lockyer, Mr. J. Norman	London, England	1880
Moissan, Prof. Henri	Paris, France	1896
Mueller, Baron Ferd. von	Melbourne, Australia	1887
Newcomb, Prof. Simon	Washington, D. C.	1891
Quatrefages, Prof. J. L. A.	Paris, France	1879
Rawlinson, Sir Henry Cresswicke	London, England	1882
Richter, Prof. Th.	Freiberg, Saxony	1876
Roscoe, Sir Henry	Manchester, England	1887
Rosenbusch, Prof. H. F.	Heidelberg, Germany	1887
Stokes, Sir George G.	London, England	1889
Szabó, Prof. Josef	Buda-Pesth, Hungary	1890
Thompson, Prof. J. J.	Cambridge, England	1896
Torell, Prof. Otto	Stockholm, Sweden	1876
Tunner, Prof. P. Ritter von	Leoben, Austria	1876
Young, Prof. Charles A.	Princeton, N. J.	1878

PATRONS OF THE ACADEMY.*

Bolton, Prof. H. Carrington	Cosmos Club, Washington, D. C.
Britton, Dr. Nathaniel Lord	In care Columbia University, New York City.
Casey, Capt. Thos. L., U. S. A.	Norfolk, Va.
Chapin, Chester W.	34 W. 57th St., New York City.
Dodge, William E.	262 Madison Ave., New York City.
Egleston, Prof. Thomas	Columbia University, New York City.
Field, C. de Peyster	127 Water St., New York City.
Gould, Edwin	Dobbs Ferry, N. Y.
Gould, Miss Helen	Dobbs Ferry, N. Y.
Herrman, Mrs. Esther	59 W. 56th St., New York City.
Hinton, John H., M. D.	41 W. 32d St., New York City.
Leeds, Prof. Albert R.	900 Hudson St., Hoboken, N. J.
Levison, W. Goold, Ph. D.	1435 Pacific St., Brooklyn, N. Y.
Prime, Frederick E.	26 Broad St., New York City.
Prime, Temple	26 Broad St., New York City.

* See By-laws, Chap. III. and Chap. VIII., Section 2.

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Senff, Chas. H.	Whitestone, N. Y.
Sloan, Samuel	26 Exchange Place, New York City.
Steward, D. Jackson	20 Gramercy Park, New York City.
Weston, Henry	29 Broadway, New York City.

FELLOWS AND RESIDENT MEMBERS.

F, Fellows; L, Life Member; P, Patron; S, Subscriber to Publication Fund. Corrected to November 2, 1896.

			Elected.
Abbott, Frank, M. D.		22 West 40th St.	1878
Alexander, Charles B.	L	120 Broadway	1896
Alexander, Henry M.	L	10 West 54th St.	1896
Allen, J. A., Ph.D.	F	Am. Mus. Nat. His.	1874
Allen, T. F., M. D.	F	10 East 36th St.	1876
Amend, B. G.	F S	120 East 19th St.	1866
Anthony, R. A.	L	591 Broadway	1895
Arnold, E. S. F., M. D.	F	Nat. Hist. Soc. Newport, R. I.	1880
Astor, Hon. John J.		23 West 26th St.	1894
Bailey, James M.		77 Madison Ave.	1863
Banks, David S.		Gilsey House	1894
Beach, Frederick C.		361 Broadway	1896
Beatty, A. Chester		3 East 9th St.	1896
Beck, F. C. T.	F L	78 East 56th St.	1868
Bickmore, A. S., Ph.D.	F	Am. Mus. Nat. Hist.	1873
Bien, Julius		140 Sixth Ave.	1876
Biggs, Charles		646 Broadway	1878
Bliss, Prof. Charles B.		University Heights	1896
Boas, Dr. Franz	F	Am. Mus. Nat. Hist.	1896
Bolton, H. Carrington, H., Ph.D.	P F	Cosmos Club, Washington, D.C.	1867
Bonnett, Charles P.		Elizabeth, N. J.	
Bridgham, Samuel W.		49 West 23d St.	1895
Bristol, Prof. Charles L.		University Heights	1894
Britton, Prof. N. L., Ph. D.	P F	Columbia University	1880
Brockway, F. J., M. D.		105 West 74th St.	1894
Brown, Hon. Addison	F	37 West 89th St.	1887
Brownell, Silas B.	F	322 West 56th St.	1869
Brownne, J. S.		19 West 43d St.	
Brush, Charles B.		349 West 56th St.	1888
Burr, Prof. W. H.		Columbia University	1893
Butler, Prof. N. M.		Columbia University	1896

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Carpenter, Prof. Wm. H.		Columbia University	1896
Casey, Capt. Thos. L.	P F	Norfolk, Va.	1887
Caswell, John H.	F	11 West 48th St.	1869
Cattell, Prof. J. McK.		Columbia University	1894
Chandler, Prof. C. F.	F	Columbia University	1865
Chapin, Chester W.	P	34 West 57th St.	1895
Chapman, Frank M.		Am. Mus. Nat. Hist.	1892
Cheeseman, Timothy M., M. D.		Columbia University	1894
Chester, Prof. Albert H.		New Brunswick, N. J.	1891
Colby, Prof. Charles E., Ph. D.		Columbia University	1883
Collingwood, Francis, C. E.	F S	Elizabeth, N. J.	1871
Conkling, Hon. Alfred R.		27 East 10th St.	1876
Constant, S. Victor	L	420 West 23d St.	1887
Cooper, Hon. Edward		12 Washington Sq., N.	1867
Coster, C. H.	L	27 West 19th St.	1895
Cox, Hon. C. F.	F	54 East 67th St.	1876
Crampton, H. E.		Columbia University	1894
Crooke, John J.	F	186 Grand St.	1867
Crow, A. Eugene		2 West 53d St.	1893
Curtis, Henry S.		Columbia University	1894
Curtis, John G., M. D.		327 West 58th St.	1892
Daly, Hon. Charles P., LL.D.	F	84 Clinton Place	1868
Davies, Wm. G.		34 Nassau St.	1876
Davis, J. W., Ph. D.		417 Madison Ave.	1892
Dean, Prof. Bashford		Columbia University	1888
Dederick, E. H.		16 Maiden Lane	1877
Dennett, W. S., M. D.		8 East 49th St.	1896
De Witt, Wm. G.		88 Nassau St.	1884
Dickerson, E. N.	F L	64 East 34th St.	1895
Diehl, Mrs. Anna R.		506 145th St.	1880
Dittenhoefer, A. J.		Room 140, 96 Broadway	1878
Dix, Rev. Morgan, S. T. D.		27 West 25th St.	1877
Dodge, Prof. R. E.		Teachers' College	1895
Dodge, Wm. E.	P S	262 Madison Ave.	1867
Donald, James M.		11 Nassau St.	1896
Doremus, Prof. Chas. A.	F	49 East 29th St.	1876
Doremus, Prof. R. Ogden, M. D.	F	241 Madison Ave.	1867
Douglass, Andrew E.	F	9 East 54th St.	1881
Douglas, James	L	99 John St.	1896
Drummond, Isaac W., M. D.		436 West 22d St.	1877
Dudley, Henry	F	56 West 57th St.	1884
Dudley, P. H.	F	80 Pine St.	1884

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			Elected.
Dunham, E. K., M. D.		338 East 26th St.	1890
Dwight, Jonathan, Jr., M. D.		2 East 34th St.	1888
Dyar, Harrison G.		234 West 99th St.	1893
Dyckman, I. M.		15 East 71st St.	1895
Egleston, Prof. Thomas	P F	Columbia University	1861
Elliott, Prof. A. H., Ph. D.	L	4 Irving Place	1881
English, Geo. L.		64 East 12th St.	1892
Eyerman, John		Easton, Pa.	1890
Fargo, James C.		56 Park Ave.	1878
Farrand, Dr. Livingston		Columbia University	1895
Farrar, John N., M. D.		1271 Broadway	1888
Field, C. De Peyster	P	127 Water St.	1869
Fiske, Thomas S.		Columbia University	1889
Ford, James B.	L	507 Fifth Ave.	1895
Foster, L. S.		35 Pine St.	1893
Foster, Scott		332 West 72d St.	1896
Freeborn, George C., M. D.		215 West 70th St.	1894
Frissell, A. S.		520 Fifth Ave.	1896
Garretson, Francis T.		26 Broad St.	1890
Gibier, Paul, M. D.		5 West 97th St.	1892
Gibson, Capt. W. W., U. S. A.		Cleveland, Ohio	1889
Giddings, Prof. F. H.		Columbia University	1896
Godkin, E. L.		36 West 10th St.	1896
Goldschmidt, Dr. S. A.		12 East 58th St.	1890
Gordon, Reginald		Columbia University	1896
Gould, Edwin	P	Dobbs Ferry, N. Y.	1895
Gould, Frank J.		Irvington, N. Y.	1896
Gould, George J.		1 East 47th St.	
Gould, Miss Helen	P	Irvington, N. Y.	1896
Gouley, J. W. S., M. D.		11 East 43d St.	1867
Greacen, Thomas E.		65 West 48th St.	1896
Green, Hon. Andrew H.		214 Broadway	1865
Greene, Jeanette B., M. D.		75 West 55th St.	1890
Gudeman, Edward		40 East 69th St.	1890
Hale, Albert W.		81 Clinton Place	1869
Hall, Prof. Robert W.		University Heights	1888
Hallock, Prof. William		Columbia University	1893
Hascall, Mrs. Virginia		110 East 16th St.	1881
Havemeyer, Wm. F.		29 West 19th St.	1896
Heineman, Henry N., M. D.		3 East 14th St.	1880

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			Elected.
Hering, Prof. Daniel W.		University Heights	1896
Herrman, Mrs. Esther	P S	59 West 56th St.	1881
Herter, C. A., M. D.		839 Madison Ave.	1894
Hewitt, Hon. A. S., LL. D.	F	9 Lexington Ave.	1868
Hinton, John H., M. D.	P F	41 West 32d St.	1865
Hitchcock, Miss F. R. M.	F	300 William St., E. Orange, N.J.	1881
Hoe, Henry	S	91 John St.	1878
Hoffman, Rev. E. A., D. D.	L	1 Chelsea Sq.	1895
Hollick, Arthur	F	Columbia University	1891
Holt, Henry	L	27 West 23d St.	1896
Hooper, Prof. F. W.		71 St. James Place, Brooklyn	
Hornaday, William		69 Wall St.	1896
Hoyt, Alfred M.		1 Broadway	1878
Hubbard, Prof. O. P., M. D.	F	123 W. 55th St.	1874
Hubbard, Walter C.		Room 25, Cotton Exchange	1876
Humason, H. A., M. D.		42 West 76th St.	1896
Huntington, Prof. George S., M. D.		College of Phy. and Surgeons	1892
Hyde, E. Francis		835 Fifth Ave.	1881
Iles, George	L	Park Avenue Hotel	1895
Ireland, John B.		170 Broadway	1876
Jackson, Prof. A. V. W.		Columbia University	1896
Jacobi, Abram, M. D.	F	110 West 34th St.	1867
Jacoby, Prof. Harold	F	Columbia University	1891
James, D. Willis		40 East 39th St.	1876
Jesup, Morris K.		197 Madison Ave.	1893
Jones, C. N.		127 West 58th St.	1893
Julien, Alexis A.	F S	Columbia University	1867
Kane, S. Nicholson		Knickerbocker Club	1895
Kemp, Prof. James F.	F	Columbia University	1891
Kunz, George F.	F	15 Union Square	1876
Lamb, Osborn R.	L	356 West 22d St.	1890
Laudy, Louis H.		Columbia University	1881
Lawton, James M., Jr.	L	37 Fifth Ave.	1895
Lederle, Ernst J.		120 West 90th St.	1891
Ledoux, Albert R.	F	9 Cliff St.	1888
Lee, Prof. F. S., M. D.		Col. of Phys. and Surgeons	1892
Leeds, Prof. A. R.	P F	900 Hudson St., Hoboken, N. J.	1872
Lembke, Charles F.		21 Union Square	1895
Levine, Edmund J.		23 East 72d St.	1896
Levison, W. Goold, Ph.D.	P F	1435 Pacific St., Brooklyn	1872

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			Elected.
Lewis, Walter H., Jr.		63 West 19th St.	1885
Liautard, Prof. A., M. D.		141 West 54th St.	1869
Lichtenstein, Paul		48 Exchange Place	1876
Loeb, Prof. Morris		118 W. 72d St.	1892
Lord, Benj., M. D.		34 West 28th St.	1885
Love, E. G., Ph.D.		80 East 55th St.	1896
Low, President Seth, LL. D.		Columbia University	1876
Luquer, Lea McI.		Columbia University	1892
Macdonald, John	F	39 Broadway	1882
Macy, C. A., 2d		208 West 45th St.	1895
Marble, Manton		532 Fifth Ave.	1878
Marié, Peter		6 East 37th St.	1895
Marquand, Henry G.	F	11 East 68th St.	1876
Martin, Daniel S.	F	75 West 55th St.	1868
Mayer, Prof. A. M.		Stevens Institute, Hoboken, N.J.	1894
McClintock, Emory, LL. D.	F	32 Nassau St.	1889
McCook, Col. J. J.	L	10 W. 54th St.	1896
McLouth, Prof. Lawrence A.		University of New York	1896
Mead, Walter H.		65 Wall St.	1882
Meltzer, S. J., M. D.		66 East 124th St.	1896
Merrill, Fred. J. H.	F	State Museum, Albany, N. Y.	1886
Meyer, T. C., C. E.		Union Club	1895
Mitchell, Edward		31 East 50th St.	1876
Mitchell, John Murray		35 Wall St.	
Morgan, Hon. J. Pierpont		219 Madison Ave.	1891
Morse, J. H.		423 Madison Ave.	1881
Moses, Prof. Alfred J.		Columbia University	1892
Munsell, C. E.		110 Horatio St.	1885
Nash, Stephen P.		67 Wall St.	1891
Newton, H. J.	F	45 Cedar St.	1871
Niven, Wm.		733 Broadway	1893
Nott, F. J., M. D.		544 Madison Ave.	1878
Olcott, E. E.	L	18 Broadway	1896
Osborn, Henry F.	F	Columbia University	1892
Otis, Prof. F. N., LL.D.	F	51 West 50th St.	1867
Ottendorfer, Oswald		150 West 59th St.	1878
Parker, H. C.		Columbia University	1895
Parmly, D. D.		160 Broadway	1879
Parsons, John E., Esq.		111 Broadway	1896
Patten, John	L	Baltimore, Md.	1894

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Peabody, Hon. C. A.		70 West 21st St.	1879
Pell, Alfred		20 East 35th St.	1896
Pellew, C. E.	F	68 East 54th St.	1883
Perry, Prof. Edward D.		Columbia University	1896
Pettigrew, D. L.		Box 1004, Worcester, Mass.	1896
Pfister, J. C.		Columbia University	1895
Phœnix, Lloyd,		Union Club	1895
Pierson, Israel C., Ph. D.	F	21 Cortlandt St.	1892
Piffard, Dr. Henry G.		10 West 35th St.	1896
Pitkin, Lucius		138 Pearl St.	1884
Post, C. A.		21 Washington Sq., N.	1891
Post, George B.		11 West 21st St.	1895
Potter, Hon. O. B.		3 East 57th St.	1889
Price, Prof. Thomas R.		Columbia University	1896
Prime, F. E.	P	26 Broad St.	1864
Prime, Temple	P S	26 Broad St.	1852
Prince, Prof. John D.		19 West 34th St.	1896
Prudden, Prof. T. M., M. D.		Columbia University	1894
Pupin, Prof. M. I.		Columbia University	1890
Quackenboss, J. D.		331 West 28th St.	1890
Rees, Prof. John K.	F	Columbia University	1882
Rice, Prof. Charles		Bellevue Hospital	1876
Ricketts, Prof. P. De P.	F	Columbia University	1871
Ries, Heinrich		305 East 53d St.	1892
Riley, R. Hudson		Bensonhurst, N. Y.	1890
Ripley, John H., M. D.		605 Lexington Ave.	1884
Rusby, Prof. Henry H., M. D.	F	College of Pharmacy	1889
Sabine, Wm. T., Jr.		960 Madison Ave.	1896
Satterlee, Livingston		New Brightom, Staten Is.	1859
Schemerhorn, F. A.		61 University Place	1867
Schemerhorn, Wm. C.		49 West 23d St.	1891
Schoonmaker, Wm. D.		28 Warren St.	1888
Schuyler, Philip		Irvington, N. Y.	1876
Senff, C. H.	P	Whitestone, N. Y.	1895
Serrell, Lemuel W.		140 Nassau St.	1876
Shriver, Walter		333 East 56th St.	1878
Shultz, Carl H.		445 First Ave.	1878
Sieberg, W. H. J.		158 East 124th St.	1877
Silver, Lewis Mann, M. D.		103 West 72d St.	1896
Skeel, Frank D., M. D.		361 Mott Ave.	1890
Sloan, Samuel	P	26 Exchange Place	1876

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Smith, Ernest E., M. D.		157 East 74th St.	1894
Starr, Prof. M. Allen		22 West 48th St.	1894
Stetson, F. L.	L	576 Madison Ave.	1895
Stevens, George T., M. D.		33 West 33d St.	1882
Stevens, Prof. W. LeConte	F	Rensselaer Poly. Inst, Troy, N.Y.	1882
Stevenson, Prof. J. J.	F	468 West End Ave.	1880
Steward, D. Jackson	P	20 Gramercy Park	1858
Stoddard, Prof. F. H.		University Heights	1896
Stokes, James		49 Cedar St.	1896
Stratford, Prof. Wm.		245 West 52d St.	1895
Strong, Charles A.		Hotel San Remo	1896
Stuyvesant, Rutherfurd		246 East 15th St.	1868
Sutro, Mrs. Mathilde		60 West 49th St.	1890
Taggart, Rush, Esq.		319 West 75th St.	1896
Tatlock, John, Jr.	F	Box 194, New York City	1891
Taylor Charles Fayette, M. D.	F	201 West 54th St.	1876
Taylor, Henry L., M. D.		201 West 54th St.	1877
Terry, James		New Haven, Conn.	1883
Thompson, Prof. W. Gilman		University of New York	1895
Todd, A. J.		261 Broadway	1878
Todd, Prof. H. A.		Columbia University	1896
Tows, C. D.		Buckingham Hotel	1878
Trotter, Alfred W.		26 Cortlandt St.	1875
Trowbridge, Charles C.		Columbia University	1894
Tuckerman, Alfred		342 West 57th St.	1892
Valentine, Philip J., Ph. D.		351 Lenox Ave.	1882
Van Buren, Fred. T.		21 West 14th St.	1880
Van Brunt, Cornelius	F	319 East 57th St.	1876
Van Giesen, Ira, M. D.		Columbia University	1894
Van Ingen, Gilbert		Columbia University	1896
Van Nardroff, Prof. E. R.		89 Quincy St., Brooklyn	1895
Van Slyck, George W.		120 Broadway	1878
Vulté, H. T., Ph. D.	F	Columbia University	1890
Wade, H. T.		Columbia University	1895
Wall, John L.	F	338 Sixth Ave.	1879
Waller, Elwyn, Ph. D.	F	440 First Ave.	1871
Ward, Delancy W.		Columbia University	1893
Weston, Henry	P	29 Broadway	1865
Weston, Theodore		14 East 48th St.	1896
Wheeler, Prof. J. R.		Columbia University	1896

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White, Thaddeus R.		257 West 45th St.	1896
White, Theodore G.		39 West 26th St.	1894
Whitfield, Prof. R. P.	F	Am. Mus. Nat. History	1879
Whiton, Louis C., Esq.		114 West 76th St.	1896
Wiechmann, F. G.	F	Columbia University	1882
Wiener, Joseph. M. D.		1046 Fifth Ave.	1876
Wilson, Prof. Edmund B.		Columbia University	1893
Wood, Isaac F.		Rahway, N. J.	1878
Wood, Wm. H. S.		45 East 10th St.	1865
Woodhull, Prof. John F.		Teachers' College	1896
Woodward, Prof. R. S.		Columbia University	1893
Wortman, J. L., M. D.		Am. Mus. Nat. History	1892
Wurtz, Prof. Henry		2149 Seventh Ave.	1869
Youmans, Wm. J., M. D.	F	72 Fifth Ave.	1877

CORRESPONDING MEMBERS OF THE NEW YORK ACADEMY OF SCIENCES, 1896.

		Elected.
Abbe, Prof. Cleveland	Washington, D. C.	
Abbott, Dr. Chas. C.	Trenton, N. J.	1883
d'Achiardi, Prof. Antonio	University of Pisa, Italy	1883
Alexander, Prof. W. D.	Honolulu, Hawaiian Islands	1890
Am Ende, Dr. C. G.	Hudson City, N. J.	1874
Angas, Geo. French	London, England	1864
Appleton, Prof. John H.	Providence, R. I.	1876
Austen, Prof. Peter T.	Poly. Inst. Brooklyn, N. Y.	1878
Ayres, Dr. W. O.	New Haven, Conn.	1864
Balch, Geo. T.	New York, N. Y.	1876
Ball, Prof. Valentine	Dublin, Ireland	1885
Bayle, Prof. E.	School of Mines, Paris, France	1868
Bechler, Lieut. W. H.	Newport, R. I.	1880
Bell, J. Graham	Washington, D. C.	1878
Berthoud, Edw. L.	Golden City, Col.	1867
Bertrand, Prof. Emile	Rue de Tournon, Paris, France	1883
Bishop, Nath. H.	Lake George, N. Y.	1869
Bolles, Rev. E. C.	Salem, Mass.	1865
Bolton, Dr. Meade	Richmond Hill, N. Y.	1890
Bombicci, Prof. Luigi	University of Bologna, Italy	1883
Boni, Giacomo	Venice, Italy	1886
Brandegee, Townsend S.	Cañon City, Colo.	1874

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Branner, Prof. J. C.	Stanford University, Cal.	1884
Brewster, Wm.	Cambridge, Mass.	1874
Brunet, Dr.	Bahia, Brazil	1867
Brush, Prof. Geo. J.	New Haven, Conn.	1876
Buck, C. Elton	Wilmington, Del.	1866
Caldwell, Prof. George C.	Ithaca, N. Y.	1876
Carmichael, Prof. Henry	Boston, Mass.	1876
Cary, Prof. Albert A.	Bridgeport, Conn.	1890
Chandler, Prof. W. H.	Bethlehem, Pa.	1876
Chapman, A. W., M. D.	Apalachicola, Fla.	1836
Chapman, Prof. E. J.	Toronto, Canada	1877
Clarke, Prof. F. W.	Washington, D. C.	1876
Clay, Joseph A.	Philadelphia, Pa.	1857
Collett, Prof. John	Indianapolis, Ind.	1880
Comstock, Prof. Theo. B.	Tucson, Ariz.	1877
Cooke, Dr. M. C.	London, England	1868
Cooper, Dr. James G.	Hayward, Cal.	1855
Cope, Prof. Edward D.	Philadelphia, Pa.	1876
Cornwall, Prof. H. B.	Princeton, N. J.	1876
Cory, Charles B.	Boston, Mass.	1880
Cox, Kenyon	Anaheim, Cal.	1880
Crawford, Jos. A.	Davenport, Iowa	1877
Credner, Prof. Hermann	Leipsic, Saxony	1866
Crosse, H.	Paris, France	1864
Cushing, Prof. H. P.	Adelbert Coll., Cleveland, O.	1895
Dale, T. Nelson	Williamstown, Mass.	1879
Dall, Prof. William H.	Washington, D. C.	1870
Dana, Arnold Guyot	Brooklyn, N. Y.	1887
Dana, Prof. Edward S.	New Haven, Conn.	1885
Deane, Ruthven	Cambridge, Mass.	1874
Derby, Prof. Orville A.	São Paulo, Brazil	1890
Devine, Dr. S. R.	Lake Sheldrake, N. Y.	1867
Douglass, Prof. Silas H.	Ann Harbor, Mich.	1876
Dow, Capt. John M.	New York, N. Y.	1869
Drown, Pres. Thomas M.	Bethlehem, Pa.	1876
Drummond, Prof. Henry	Glasgow, Scotland	1887
Duns, Prof. John	Edinburgh, Scotland	1868
Edsall, Burroughs	Spuyten Duyvil, N. Y.	1884
Edwards, Dr. Arthur M.	Newark, N. J.	1873
Elliot, Daniel G.	New York City	1860
Elliot, Henry W.	Washington, D. C.	1876

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Elliott, Prof. John B.	Sewanee, Tenn.	1880
Engelhardt, Dr. Francis E.	Syracuse, N. Y.	1869
Ernst, Dr. Adolfo	Caracas, Venezuela	1878
Fairchild, Prof. H. Leroy	Rochester, N. Y.	1879
Fay, H. F.	Columbus, O.	1858
Fensi, Cav. Sebastiano	Florence, Italy	1887
Fink, Albert	Louisville, Ky.	1890
Fittica, Prof. F.	Univ. of Marburg, Germany	1879
Fletcher, Prof. Lazarus	London, England	1885
Ford, Prof. Darius R.	Elmira, N. Y.	1874
Ford, Silas W.	Schodack Landing, N. Y.	1873
Fresenius, Prof. C. R.	Wiesbaden, Germany	1879
Fritz-Gaertner, Dr. R.	Tegucigalpa, Honduras	1879
Gadolin, Gen. Alex.	St. Petersburg, Russia	1868
Gaussoin, E.	Baltimore, Md.	1867
Gilbert, G. K.	Washington, D. C.	1870
Gill, Dr. Theodore	Washington, D. C.	1858
Gilman, Pres. D. C.	Baltimore, Md.	1876
Goessman, Prof. C. A.	Amherst, Mass.	1865
Gooch, Prof. F. Austin	New Haven, Conn.	1888
Gordon, Dr. Antonio de	Havana, Cuba	1883
Grattarola, Prof. Guiseppe	Florence, Italy	1883
Green, S. F.	Jaffna, Ceylon	1867
Greenleaf, R. C.	Boston, Mass.	1868
Gregg, Dr. Wm. H.	Elmira, N. Y.	1865
Gregorio, Marchese Antonio di	Palermo, Sicily	1883
Grierson, T., M. D.	Dumfriesshire, Scotland	1865
Grote, Prof. Aug. R.	Buffalo, N. Y.	1876
Grote, Prof. Paul	Munich, Germany	1877
Gudeman, Dr. Edward	Philadelphia, Pa.	1890
Gunning, Thos. B.		1878
Guppy, R. J. L.	Trinidad, W. I.	1869
Hagen, Dr. Herman A.	Cambridge, Mass.	1874
Hague, James D.	New York, N. Y.	1874
Hamlin, Chas. E.	Cambridge, Mass.	1865
Hanley, Sylvanus	London, England	1864
Hardin, M. B.	Lexington, Va.	1866
Hawkins, B. Waterhouse	London, England	1868
Hayes, S. Dana	Boston, Mass.	1876
Hesse-Wartegg, Count Ernst von	New York	1882
Hexamer, Dr. F. M.	New Rochelle, N. Y.	1857

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Hidden, Wm. Earl	Newark, N. J.	1875
Hill, Prof. Henry B.	Cambridge, Mass.	1876
Himes, Prof. Charles F.	Carlisle, Pa.	1876
Hitchcock, Prof. Charles H.	Hanover, N. H.	1867
Horsford, Prof. E. N.	Cambridge, Mass.	1876
Horton, Letas R.	Goshen, N. Y.	1864
Hoskold, Prof. H. D.	Buenos Ayres, South America	1890
Howard, Thomas T., Jr.	Perth Amboy, N. J.	1877
Hyatt, Prof. Alpheus	Cambridge, Mass.	1876
Hyatt, Prof. James	Stanfordville, N. Y.	1876
Iles, Malvern W.	Denver, Col.	1875
James, Major O. C.	Rio Janeiro, Brazil	1867
Jannetaz, Prof. A.	Sorbonne, Paris, France	1883
Jesup, Rev. Henry Griswold	Hanover, N. H.	1885
Johnson, Prof. Samuel	New Haven, Conn.	1876
Jordan, Pres. David S.	Stanford University, Cal.	1876
Judd, Orange	Middletown, Conn.	1876
Kellicott, D. S.	Buffalo, N. Y.	1886
Kendrick, Prof. H. L., U. S. M. A.	West Point, N. Y.	1876
Kinney, Prof. J. R.	Honolulu, Sandwich Islands	1867
Knowlton, W. J.	Boston, Mass.	1880
Koenig, Prof. George A.	Houghton, Mich.	1876
Koltzoff-Massalsky, Princess Hélène	Florence, Italy	1887
Koschkull, H. von	Tiflis, Caucasus	1868
Krebs, H. J.	Copenhagen, Denmark	1867
Krontschoff, Baron K. de	St. Petersburg, Russia	1890
Kuki, R.	Tokio, Japan	1888
Kulibin, Prof. N.	St. Petersburg, Russia	1890
Kulibin, Prof. S	St. Petersburg, Russia	1890
Laarda, Antonio de	Bahia, Brazil	1867
Lacroix, Alfred	Paris, France	1890
Land, Wm. J.	Atlanta, Ga.	1877
Langley, Prof. J. W.	Ann Arbor, Mich.	1876
Lattimore, Prof. S. A.	Rochester, N. Y.	1876
Lauderdale, J. V., M. D.	U. S. A.	1867
Laussedat, Col.	Paris, France	1890
Lea, M. Carey	Philadelphia, Pa.	1876
LeConte, Prof. Joseph	Berkeley, Cal.	1876
Le Jolis, Dr. Auguste	Cherbourg, France	1876
Le Mercier, Dr. F. G.	Paris, France	1869

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Lintner, Prof. J. A.	Albany, N. Y.	1872
Lockwood, Rev. Samuel	Freehold, N. J.	1865
Lowe, Edward J.	Nottingham, England	1857
Lupton, Prof. N. T.	Nashville, Tenn.	1876
Mackie, Simon F.	Salt Lake City, Utah	1869
Macloskie, Prof. George	Princeton, N. J.	1876
Mallet, Prof. John W.	University of Virginia, Va.	1876
Mann, C. Riborg	Univ. of Chicago, Chicago, Ill..	1896
Marcy, Prof. Oliver	N.W.University, Evanston, Ill.	1871
Marsh, Prof. O. C.	New Haven, Conn.	1867
Mason, Rev. Francis	Tavoy, Burmah	1844
Matthew, Mr. George F.	St. John, N. B.	1867
Maynard, C. J.	Boston, Mass.	1874
McChesney, Prof. J. H.	Chicago, Ill.	1863
McCormick, Richard H.	Arizona	1869
McMurtrie, W. C., M. D.	Washington, D.C.	1876
Mead, Theodore L.	Eustis, Florida	1874
Meek, Prof. Seth E.	Cedar Rapids, Iowa	1888
Meneghini, Prof. G.	Pisa, Italy	1888
Merriam, Prof. C. Hart	Washington, D.C.	1874
Merrick, Prof. J. M.	Boston, Mass.	1876
Meyer, Dr. A. B.	Dresden, Germany	1890
Michie, Prof. P. S.	West Point, N. Y.	1885
Minot, Dr. Charles S.	Boston, Mass.	1878
Mixter, Prof. Wm. G.	New Haven, Conn.	1876
Moldenke, Richard G. G.	Houghton, Mich.	1890
Morch, Otto	Copenhagen, Denmark	1864
Morse, Prof. Edward S.	Salem, Mass.	1864
Mortimer, Capt. John H.	New York	1875
Netto, Prof. Ladislau	Rio Janeiro, Brazil	1890
Nevius, Rev. Reuben D.	Baker City, Oregon	1867
Newton, Prof. Alfred	Cambridge, England	1866
Nicholls, Dr. H. A. Alfred	Dominica, W. I.	1882
Nicolis, Sig. Cav. Enrico	Verona, Italy	1884
Niles, Prof. Wm. H.	Boston, Mass.	1881
Nolan, Dr. Edward J.	Philadelphia, Pa.	1880
Nordenskjöld, Prof. N. A. E.	Stockholm, Sweden	1868
Ober, Frederick A.	Beverly, Mass.	1879
Oothout, Henry	Stamford, Conn.	1865
Ordway, Prof. John M.	New Orleans, La.	1876
Orton, Prof. Edward	Columbus, O.	1871
Ostensacken, Baron R.	St. Petersburg, Russia	1857

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Packard, Prof. A. S., Jr.	Providence, R. I.	1866
Packard, R. L.	Washington, D. C.	1877
Paine, Prof. John A.	Tarrytown, N. Y.	1877
Parrott, Rev. Dr. J. W.	Addison, Steuben Co., N. Y.	1869
Peckham, Prof. S. F.	Ann Arbor, Mich.	1876
Perkins, Prof. Maurice F.	Schenectady, N. Y.	1876
Phene, Dr. J. S.	London, England	1882
Pickering, Prof. Ed. C.	Cambridge, Mass.	1876
Pisani, F.	8 Rue Furstenburg, Paris, France	1883
Poey, Prof. Andreas	Paris, France	1869
Post, Prof. George E.	Beirut, Syria	1888
Potter, Prof. W. B.	St. Louis, Mo.	1871
Prescott, Prof. Albert B.	Ann Arbor, Mich.	1876
Prime, Prof. Frederick, Jr.	Easton, Pa.	1877
Pumpelly, Prof. Raphael	Newport, R. I.	1868
Purdie, H. A.	Boston, Mass.	1874
Putnam, Prof. F. W.	Cambridge, Mass.	1860
Pynchon, Prof. Th. R.	Hartford, Conn.	1876
Ramsey, J. G., M. D.	Tennessee	1860
Randall, F. A.	Warren, Pa.	1876
Rawson, Sir Rawson W.	London, England	1867
Read, Matthew C.	Hudson, Ohio	1876
Reade, T. Mellard	Liverpool, England	1888
Remsen, Prof. Ira	Baltimore, Md.	1876
Ridgway, Robert	Washington, D.C.	1874
Robb, Prof. Wm. Lispenard	Hartford, Conn.	1886
Robertson, J.	Atticus, N. Y.	1864
Roemer, Edward, M. D.	Cassel, Germany	1864
Rogers, F. M.	Luling P. O., Louisiana	1877
Rogers, Dr. Henry R.	Dunkirk, N. Y.	1882
Rosa, W. V. V., M. D.	Watertown, N. Y.	1866
Russell, Prof. Israel C.	Ann Arbor, Mich.	1879
Sadtler, Prof. Samuel P.	Philadelphia, Pa.	1876
Salvadore, T., M. D.	Turin, Italy	1866
Schaeffer, Pres. C. A.	Iowa City, Iowa	1876
Schweitzer, Dr. Paul	Univ. of Mo., Columbia, Mo.	1867
Scudder, Prof. Samuel H.	Cambridge, Mass.	1876
Sherwood, Andrew	Mansfield, Pa.	1876
Slosson, Charles	Buffalo, N. Y.	1885
Smith, Charles E.	Philadelphia, Pa.	1866
Smith, J. Ward	Newark, N. J.	1883

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Smith, Sanderson	Staten Island, N. Y.	1854
Smith, T. L., M. D.	U. S. N.	1849
Smyth, Prof. C. H., Jr.	Clinton, N. Y.	1895
Spang, Norman	Etna, Allegheny Co., Pa.	1876
Spencer, Rev. J. Selden	Tarrytown, N. Y.	1890
Stearns, Robert, E. C.	Berkeley, Cal.	1896
Stevens, Dr. Robert P.	Brooklyn, N. Y.	1875
Stoebner, Prof. F. W.	Westfield, Mass.	1882
Stover, Prof. F. H.	Jamaica Plains, Mass.	1876
Stretch, Richard H.	San Francisco, Cal.	1865
Stuart, A. P. S.	Lincoln, Neb.	1876
Tajore, The Maharajah Sowindho Mokun	Calcutta, India	1885
Thurston, Sir John	Gov. General Fiji Islands	1887
Thurston, Prof. Robert H.	Ithaca, N. Y.	1876
Thwing, Rev. Edward P.	Brooklyn, N. Y.	1885
Torrey, H. Gray	Stirling, N. J.	1866
Trowbridge, Prof. John	Cambridge, Mass.	1877
Tryon, A. W.	Philadelphia, Pa.	1873
Tryon, G. W., Jr.	Philadelphia, Pa.	1864
Tuttle, Prof. D. K.	Baltimore, Md.	1876
Van Heurck, Henri	Antwerp, Belgium	1871
Verrill, Prof. A. E.	New Haven, Conn.	1867
Vogdes, Capt. A. W.	Fort Canby, Wash.	1890
Volhard, Prof. Jakob	Univ. of Munich, Germany	1879
Vollum, Dr. Edw. P.	Jefferson Barracks, Mo.	1880
Voss, Lothair	Berliburg, Prussia	1869
Waldo, Leonard	Bridgeport, Conn.	1876
Ward, James W.	Buffalo, N. Y.	1876
Ward, Prof. Henry A.	Rochester, N. Y.	1888
Warring, Prof. Charles B.	Poughkeepsie, N. Y.	1876
Webber, Thomas	Kelleyville, Ireland	1887
Weissbach, Prof. A.	BergAkademie, Freiberg, Saxony	1883
White, Prof. I. C.	Morgantown, W. Va.	1874
Winchell, Prof. N. H.	Minneapolis, Minn.	1878
Wissman, J. F.	San Francisco, Cal.	1869
Wood, Horatio C., M. D.	Philadelphia, Pa.	1866
Woodward, Henry	London, England	1868
Wormley, Dr. Theodore G.	Philadelphia, Pa.	1875
Wright, Prof. Albert A.	Oberlin, O.	1874
Wright, Prof. Arthur W.	New Haven, Conn.	1876
Yarrow, Dr. H. C.	Washington, D. C.	1876

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INDEX.

PAGE.

Adaptation of Shells of *Crepidula* to those of *Pecten*..... 67
Adirondacks, Pre-Cambrian Topography of,..... 189
Affiliated Scientific Societies, Informal Reports..... 1
Alexander, Henry L., elected member..... 147
American Association at Springfield 1
American Museum Expedition of 1895..... 67
Amia calva 126
Anthropology, Psychology and Philology, Section organized 154
Astronomy and Physics, Section 1, 34, 63, 97, 124, 134, 147, 155
Astronomical Photographs, The reduction of..... 124
Audubon Monument, report of Committee 63, 64
Statements 65
Resolutions 65
Audubon Publication Fund...63, 131
Augen-gneiss, Bedford, N. Y.... 191

Bacteria, Notes on 148
Bauxite, Mines of Georgia and Alabama 143
Beach, Frederick C., elected member..... 147
Bibliographical Compilation..... 39
Biology, Section of 39, 66, 98, 123, 125, 137, 148, 157
Bliss, Charles B., elected member 147
Block Island, Geology of..... 16
Boas, Dr. Franz..... 97
Bristol, C. L., elected Sectional Secretary..... 66
Brown's Park Beds, Utah, Stratigraphy of..... 153

PAGE.

Butler, Nicholas Murray and others, petition for membership to form a section for Scientific Investigation in Philosophy and Philology... 70

Calciferous Rocks of Ticonderoga 20
Cape of Good Hope, Observatory 63
Cause of Chemical Reaction..... 61
Cerillos Coal Fields, near Santa Fé, N. M..... 105
Introduction..... 106
Geological Structure of the Area 107
The Eruptive Rocks..... 108
The Laramie..... 110
The White Ash Coal Bed.. 111
Boyle Mine..... 111
Lucas Mine..... 113
Cunningham Mine..... 113
White Ash Mine..... 114
The "Coking Seam"..... 115
The Cook-White Coal Bed..... 116
Characteristics of the Coals... 117
Chemical Composition of the White Ash Bed 119
Chemical Composition of the Cook-White Bed..... 119
Cause of the Metamorphism of the Coal..... 120
Chazy Rocks at Chazy..... 22
Chazy Rocks at Basin Harbor.... 23
Chazy Rocks at Highgate Springs 22
Chazy Rocks at Isle La Motte... 22
Chazy Rocks at Plattsburgh..... 21
Cirripedes, Occurrence of in Cambrian Rocks..... 144
Committee for Election of Sectional Officers..... 39
Corresponding Secretary's Report..... 133
Council Action Regarding Proposed Reception..... 1

Digitized by Google

PAGE.
Council Action Regarding Lecture Course..... 1
Crepidula, Peculiar Growth..... 40
Cretaceous Strata at Glen Cove, L. I..... 10
Cretaceous Strata at Marshfield, Mass..... 10
Cripple Creek Gold Mines..... 127
Curtis, J. G., Elected Sectional Chairman..... 66
Cushing, Prof. H. P., elected corresponding member..... 63

Dennett, W. S., M. D., elected member..... 134
Dinichthys, Vertebral Column, 157
Fins and Ventral armoring of..... 157
Anterior Ventrals..... } 159
Posterior " ..... }
Notochordal Area and Vertebral Arches..... 161
Supporting Elements of the Dorsal and Pelvic Fin..... 162
Distinction between ontogenic and phylogenic variation ... 141
Changes by environment..... 142
Dodge, R. E., elected member... 34
Dogfish, Anatomy of the Ear of 176
Sacculus..... 177
Lagena..... 178
Utriculus..... 178
Sinus utriculus..... 178
Recessus utriculus..... 179
Semicircular Canals..... 179
Ampullæ..... 180
Nerve Supply..... 180
Explanation of Figures..... 181
Donald, James M., elected member..... 147
Douglass, James, elected member..... 147

Earthworm, lime gland of..... 126
Election of Officers 1896-97..... 133
Eruptive Rocks, Cerrilos, N. M. 121
Eta Cassiopeiæ, Suggestions, etc..... 35
Evolution, requiring neither Natural Selection nor Acquired Characters..... 148

Farrand, Dr. Livingston, elected Secretary of sub-section of Anthropology and Psychology..... 154
Faunas of the Upper Ordovician Strata at Trenton Falls, Oneida, Co., N. Y..... 71
History of the term "Trenton Limestone"..... 71
Original descriptions of the type Section..... 72
Stratigraphy of the Trenton Falls Section, with faunal lists..... 74
Stratigraphy, Poland Bridge Section, etc..... 81
Stratigraphy, Poland Limekiln Section, etc..... 82
Stratigraphy, Rathbone Brook Section, etc..... 84
Conclusions..... 87
Summary..... 88
Physical features of the Trenton Falls Section..... 89
List of fossils for which Trenton Falls is the type locality..... 91
Table of faunas of the Various Zones..... 93
Plates II–V.
Formalin in Injecting Media, use of..... 99
Fort Washington Avenue and New Speedway Discoveries of rare minerals..... 105
Foster, Scott, elected member... 147
Foucault currents..... 97
Fresnel, bi-prism..... 135
Frissell, A. S., elected member.. 147

Galvanometer, Method of Measuring Alternating Currents with..... 35
Gas Film Condensed on the Surface of Solid Bodies with relation to
(1) Newton's rings of the first order: (2) Sand flotation: (3) Sand in harmonic vibration..... 97
Genetic Relations of certain Minerals of Northern New York 260
Geology, Section of 3, 50, 70, 143, 153, 188
Giddings, F. H., elected member..... 147

Digitized by Google

PAGE.
Giddings, F. H., elected permanent chairman of new section 154
Glacier Bay, Alaska, Areal Geology Notes..... 24
Introduction 24
General Geology..... 24
The Argillites..... 25
The Glacier Bay Limestone.... 26
The Quartz Diorite..... 27
Diorites..... 28
Crystalline Schists..... 28
Dikes..... 28
Comparison with other Alaskan Sections..... 29
Petrographical Notes..... 31
The Quartz Diorite..... 31
The Schists..... 33
The Dikes..... 34
PLATE I. at close of volume.
Godkin, E. L., elected member 134
Gordon, Reginald " " 134
Gould, Frank J., " " 147
Gould, Miss Helen " " 147
Greacen, Thomas E. " " 147
Great Quartz Vein at Lantern Hill, Conn..... 189

Hair Hygrometer, Use of 157
Harvard College Observatory—Photographs and Keeler's planetary photographs... 147
Hartley, Marcellus, elected member 147
Havemeyer, Wm. F., elected member 147
Heliostat 135
Heliostat with Small Mirrors.... 155
Hering, Daniel W., elected member 147
Humason, T. A., elected member 134
Huxley's bill to fix standard weights and measures..... 125
Huxley's Memorial Committee.. 39
Huxley's Memorial Fund..... 132
Huxley's Memorial Tribute..... 40

Indian Territory, Geology of..... 50
Relations between the Carboniferous of Ind. Ty. and Texas..... 50
Winslow's table of Succession 51
Dr. Chance table of Succession 52
Fuel ratios of Coal..... 54
Limestone of Indian Territory 52
Greenwood Sandstone..... 53
Booneville Stage, interest of... 53
The Grady Coal-bed..... 53
McAlester Coal-bed..... 54
Appleton and Danville Stages 54
Appalachian, Structure of Coal Field 55
Limestone Gap..... 55
Condition along the Gulf, Colorado and Santa Fé Railroad 56
Buckhorn Creek Limestone... 57
Fossils in Asphaltum..... 58
Collections by Prof. Hill 59
Ouachita Mountain System ... 59
Resemblance to Appalachian Structure 60
Granitic Area and Arbuckle Mountains..... 61
Instinct of Lower Vertebrates ... 126
Instinct, Origin of 123
Is Palaeospondylus a Cyclostome 100

Jackson, A. V. Williams, elected Secretary of Subsection of Philology 154

Lake Champlain, Geology of..... 19
Lake Champlain, Petrography and Distribution of Trap Dikes in the Region of..... 105
Lantern Hill, Mystic, Conn., Great Quartz Vein of..... 189
Law of Deflection in Steel Rails 147
Lawton, James Marsland, Jr., elected member..... 34
Levine, Edmund J., elected member 147
Leytter, Emil, elected member... 147
Librarian's Report 132
Exchanges added..... 132
Requests for Publications..... 132
Librarian's Expenses..... 133
Long Island and Nantucket, Geological Notes 3
Marine Cretaceous..... 3
Cretaceous Material in the Moraine 5
Yellow Gravel..... 5
Nantucket..... 3
Character of Morainal Material..... 7

Digitized by Google

PAGE.
General Remarks..... 6
Palæontology 7
Mollusca..... 8
Crustacea..... 9
Love, E. G., elected Member..... 134
Lunar Eclipse, Photographs of... 63

Magnetic Circuit..... 97
Marble Quarries of Western New England and Eastern New York 188
McLouth, Lawrence A., elected Member..... 147
Meetings, Annual Business Meetings..... 128
Business Meetings.....1,34, 97, 123, 128, 134, 147, 155, 272
Extra Meetings.....123, 171
Stated Meetings, 1, 3, 39, 50, 62, 66, 70, 98, 104, 125, 127, 137, 143, 146, 148, 153, 154, 157 188
Memoirs and Annals..... 133
Meteoric Stone, Kansas..... 191
Metric System, Introduction and Adoption of, by Government and the Country 124
Morgan, Prof. C. Lloyd, elected Corresponding Member ... 63

Nantucket, see under Long Island.
Natural Flora of Bronx Park.... 62
Nephelis, Classification of, in the United States..... 66
Nephridial, Structure of, in Clepsine. 126
New York City and Neighborhood, Physical Geography of 123
New Zealand, Minerals of..... 191
Nugget of Silver in Arizona..... 191

On Photographs of Geisler and Crooke's Radiant Matter tubes 156
Ophileta Complanata..... 21
Optic Nerve, in Brain of Skate.. 148
Orange Co., N. Y., Geology of... 70
Ordovician Faunas at Larrabee Point, Vt..... 20
Ordovician Faunas at Shoreham 29
Ordovician Rocks..... 19

Pacific Salmon, habits of Young 182
Palaeospondylus, Marsipobranchean characters of, positive and negative 103
Paradoxides Beds, Faunas of, in Eastern North America..... 192
Description of Genera and Species 194
Lepiditta 194
" *alata* 194
" *curta* 195
" *auriculata* 196
Ostracoda 196
Primitia, Jones..... 196
" *Acadica*..... 196
Aluta 198
" *flexilis*..... 198
Cirrepedia 198
Plumulites, Barrande... 199
" *Manuelensis*..... 200
Stenotheca, Salter..... 200
" *concentrica* 201
Radiata 202
Stenotheca triangularis..... 203
" *nasuta* 204
" *Hicksiana* 205
Cirripodites, n. gen..... 205
" *Cambrensis* 206
Explanation of Plates..... 206
Sculpture 207
Trilobita 207
Agnostus, Brongniart 207
longifrontes 210
Limbati 211
parvifrontes 212
lævigati 212
Agnostus regulus 213
Agnostus rex..... 214
" *fallax* 214
" *similis* 215
" *vir*..... 215
" *concinnus*..... 216
" *trilobatus* 216
" *acadicus*..... 217
" *declivis* 219
" *parvifrons* 220
" *tessella* 221
" *truncatus* 222
" *umbo*..... 222
" *obtusilobus.* 223
" *Davidis*..... 225
" *gibbus* 226
" *partitus*..... 227
" *acutilobus* 227
" *Nathorsti* 229
" *confluens*..... 230

Digitized by Google

PAGE.
Agnostus fissus..... 230
" *trifissus*..... 231
" *punctuosus*..... 232
" *lævigatus*..... 233
" *Terranovicus*..... 233
" *ciceroides*..... 234
" *mamilla*..... 234
" *nudus*..... 235
Microdiscus..... 235
Scheme of Relation..... 237
Microdiscus Schucherti..... 238
" *precursor*..... 359
" *Dawsoni*..... 240
" *pulchellus*..... 242
" *punctatus*..... 244
Explanation of Plates..... 245
Pell, Alfred, elected member.... 147
Peneplains, Cretaceous and Tertiary of Eastern Tennessee... 143
Petrographical Notes on Rocks from Alaska..... 23
Pettigrew, Dr. David Lyman, elected resident member..... 272
Pierson, Israel C., elected Fellow..... 134
Piffard, Henry G., elected member..... 147
Philippine Pulmonate, Varietal Tree of..... 137
Cochlostyla ovoidea..... 137
Types by bands..... 139
Correlation between Size and Color..... 139
Species from Varieties..... 140
Transmission of Acquired Characters, Problem of... 141
Evolution in fossil Cephalopods..... 141
Photometric Differences, method for determining..... 155
Planet Mars, drawings made of the markings in..... 64
Polariscope..... 135
Port Kent and Ausable Chasm... 21
Pre-Cambrian Topography of the Adirondacks..... 189
Prince, J. Dynley, elected member..... 147
Primitive Education..... 155
Problems About to Confront Astronomers of the Twentieth Century..... 146

Reduction of Astro-Photographic Plates, Best Formulæ for... 2
Remarkable Nugget of Silver.... 191
Reports of Officers..... 128
Resolution Regarding Metric System of Weights and Measures 125, 127
Results of Experiments on Metallic Spheres Falling in Water 2
Robb, Prof. W. L., Vibration of a Cord..... 135
Roentgen's Discovery..... 146
Roentgen's Rays, New Results of Experiments..... 147
Rutherfurd Photographs, Permanence of..... 147

Sabine, Wm. T., elected member..... 147
Sankaty Head, Post-Pliocene Deposits..... 10
Mollusca..... 12
School Children, Results of Measurements..... 155
Secretary's Report..... 128
Average Attendance..... 129
Elections, etc..... 129
New Section Formed..... 129
Papers Classified..... 129
Public Receptions..... 129
Publications..... 130
Sectional Officers Elected..... 144
Sectional Secretaries' Reports.... 133
Sharks, Notes on Ancestral..... 40
Silver, Louis Mann, elected member..... 147
Silver, Remarkable Nugget..... 191
Some of the Sources of Bürger's Lenore..... 271
Stoddard, Francis H., elected member..... 147
Stokes, James, elected member.. 147
Straight Scales, Errors in, the Determination of Division.. 63
Stratigraphical Relations of Brown's Park Beds, Utah... 252
Suggestions as to the Determination of the Relative Mass of the two components of the Double Star Eta Cassiopeiæ from Rutherfurd Photographic Measures..... 35
Method to be Pursued and Formula Used..... 35

Digitized by Google

PAGE.

Systems of Mechanical Units.... 34
Systems of recording field notes 19

Talc Deposits near Gouverneur, N. Y. (Origin of)..... 154
Thalassema, History of the..... Achromatic Structures..... 163
The Egg Centrosome..... 164
The Sperm Centrosome 168
The Cleavage-Figure:..... 170
Effect of Fixing Agents..... 172
Literature referred to..... 175
Description of Plates..... 175
The Etymology of Italian *Andare* and related words..... 271
"The Tradition of the Case-Forms in Chaucer's Noun." 271
Titanotherium and Metamyodon Skeletons in Amer. Mus.... 40
Titanotheres in Amer. Mus..... 66
Trap-Dikes in the Adirondacks, Pre-Cambrian and Post-Ordovician 248
Introduction 248
Present Rock Classification.... 248
Proposed change in Classification 249
The Dikes..... 249
Distribution..... 250
Scarcity north of Adirondacks 251
Summary 252
Trap Dikes of Lake Champlain.. 20
Treasurer's Report 130
Disbursements 131
Receipts 130
Triassic Coals, Metamorphism by Diabase Dikes at Egypt, N. C..... 105

PAGE.

Tribally Organized Societies, Study of 155
Trilobitic fauna of Cumberland Head 21
Trip through Marble Quarries of Western New England and Eastern N. Y..... 188

Van Ingen, Gilbert, elected member 124
Van Nardroff, E. R., elected member..... 63
Vibration of a cord..... 135
Visceral Anatomy of the following:
Myrmecaphaga jubata..... 98
Tamandua bivittata 98
Arctopithecus didactylus..... 98
Dadypus sexcinctus..... 98
Tatusia novemcincta..... 98
Manis longicaudata 98
Vivisection in the District of Columbia, Resolutions on... 272
Vocal Chords in Voice Production, Action of..... 2
Photographs of, in Action..... 2
Votes of Thanks..... 133

Weston, Th., elected member.... 147
White, Thaddeus R., elected member 147
Whiton, Louis C., elected member.. 147

X-Rays, Experiments..... 136

Zinc and Lead Mines in Southwestern Virginia..... 61

Digitized by Google

GENERAL INDEX.

No separate index of nomenclature has been prepared, although such was the plan pursued in Volumes I.–X.

Abalone-Shell, viii., 162
Aboriginal use of meteoric iron, iv., 227
Abronia, iii., 45
Absolute limit to economical expansion in steam engines, ii., 1
Abutilon holosericeum, vii., 8
Texense, vii., 8
parvulum, ix., 183
Wrightii, ix., 181
Acacia, ii., 92
Acacia, vii., 170
filicina, vii., 9
Greggii, vii., 9; ix., 184
Wrightii, ix., 184
Academy, Charter, Constitution and By-laws, iii., 153–168
By-Laws, vi., 12, 58, 66
history of, iii., 107
history of, v., 233–278
history of, vi., 146, 147
history of, vii., 1,133, 236, 237, 246
library of, iii., 70–106
library of, v., 1, 20, 164, 282
library of, vi., 12
membership of, v., 162
officers of, v., 165
seal of, v., 232
Acalephæ, v., 15–16
Acalypha hederacea, vii., 13
Acanthaceæ, vii., 12
Accessions to library, v., 1, 20, 282
Accounts of an ancient beaver pond, xiii., 177
Account of creation, Chaldean, ii., 107–110
Acentrophorus Chicopensis, vi., 127
Acer minutus, xii., 35
nigrum, ix., 10
saccharum nigrum (new), ix., 10
saccharinum nigrum, ix., 10
Acetic acid, use in analyses of zinc ores, ii., 31–36
Achætogeron Palmeri, vii., 11
Acid effusives, New Brunswick, xiv., 195
Acid, hydrazoic, x., 43
Acid secretion of fungi, v., 71–72, 114, 118
Acinetæ, ix., 34
Acipenser, vii., 257
Acipenser sturio, xiii., 69
Acleisanthes Berlandieri, ix., 181
longiflora, vii., 13
Acridine, v., 196
Acroleinureide, ii., 62
Acrothele Matthewi, var. *costata*, xiv., 128
Acrotreta gemma, xiv., 126
gemmula, xiv., 126
Actinella Bigelovii, viii., 80
odorata, viii., 78
Rusbyi, viii., 80
scaposa, viii., 80
Actiniæ, v., 34, 37
Actinic method of determination of organic matter, ii., 111–114
Actinium, v., 200

Digitized by Google

Actinolite, iii., 13, 49 ; v., 264 ; vii. 213, 224 ; viii., 59
Actinophorus Clarkii, vii., 179
Actinopterigium, xii., 121
Activity of Cretaceous teliosts, iii., 54
Adaptation of shells of Crepidula, xv., 67
Adjournment of the Academy, ix., 212
Adipocere, viii., 27
Adirondack forests, destruction of, iii., 35-37
Adirondack park, x., 111
Adirondacks, schistose rocks in, iv., 72
  geology of, xii., 19
  diatomaceous earth in, xiii., 98
  Pre-Cambrian topography of, xv., 184
Adularia, vii., 229
Adze, votive, vi., 139
Æolian rock, x., 7
Aëration of water, vi., 47-52
Aërial navigation, vii , 83
Aërolites, Winnebago Co., ix., 201
Aëronautics, development of, xii., 113
Æther (assumed element) v., 184, 185
Afghanistan, sonorous sandhills, iii., 99
Affiliated Scientific Societies, Informal reports, xv., 1
Affinity, chemical, v., 185, 187
Agaricus Americanus, v., 111
  mellus, v., 111
Agassiz Association, viii., 46
Aggassizia suavis, vii., 11
Agate, iii., 34, 62 ; viii., 161, 162
  cutting, v., 19
  from Mexico, ii., 117 ; vii., 222
Agathaumas sylvestre, ix., 28
Agatized woods from Arizona, v., 9-11 ; vi., 165, 166
Agave, ii., 92
  heterocantha, 94
  Mexicana, ix., 182
Agencies in decay of stone, ii., 74
Age of Green Pond rocks, vi., 59
  of New York Island, vii., 59, 60
  of Westchester county limestones, vii., 16
Age, Stone, x., 109
Aglossa, vii., 256
Agraulos strenuus, horizon of, xiv., 102
Agropyrum Scribneri, viii., 79
Agnostis verticillata, viii., 77
Aguilera, José G., elected corresponding member, xi., 25
Air, boiling point of, v., 191
Air Brakes, v.. 149, 150
Air, elves of the, xi., 123
Air-wave, volcanic, xiii., 83
Alaska, Boulder of rock crystal, iii., 81
  large oak-leaves, 95
  (title) xi., 77
Alauda Alpestris, ix., 129
Albertite, xiii., 26, 27
Albite, ii., 42, 119 ; vi., 130 ; vii., 221, 228, 229 ; viii., 54
  from Diabase of Staten Island, iv., 76
  in New York Island, iv, 75, 227
  in Staten Island, iv., 230
Albumenoids, x., 24
Alchemical symbols, ii., 102-104
Alchemists, v., 198
Alchemy, ii., 53, 57
  contributions of, to Numismatics, ix., 71
Alcohol, v., 179
  solidification of, 19
Alexander, Henry M., elected member, 147
Alexandrite, Ceylonese, v., 131, 132
Algæ, vii., 21
  forming Sargasso Sea, iv., 58
Alizarine, v., 193, 197
Alkali industry, v., 192
Alkaline metals, v., 215
Alkaloids, v., 195
Allanite, vii., 6 ; viii., 159, 185
  from Franklin Furnace, N. J., xiii., 102
Alleghany belt, v., 78, 79
Allen, J. A., elected Vice-President, xii., 128
Alligator, breeding habits of, xiv., 62
Allionia incarnata, vii., 13
Allium, viii., 77
  mutabile, vii., 14
Alnus oblongifolia, viii., 76
Aloe, iii., 39.
Allophane, vii., 251
Alluadite, vii., 220
Alluvium of New York Island, vii., 50, 51
Almandite, viii., 161
Almucantar, v., 235, 261

Digitized by Google

Alosa sapidissima, vii., 259
Alphabet, Egyptian origin of, v., 81–88
Alphabetical, list of New York Minerals, vii., 234
Altars, stone, ix., 97
Alternations of geological climate, iii., 94–96
of temperature in North America, 96
Altitudes of Catskill Mountains, i., 25
Altitudes in the Shawangunk range, iii., 22
Alumina, vi., 7–11 ; vii., 37
Aluminum and its alloys, xii., 25
ingot of, i., 181 ; v., 192 ; vii., 220
Alytes, xii., 245
Amœbæ, structure and motions, ii., 79–82
Amalgamation of silver ores, ii., 1, 2
Amarantus fimbriatus ix., 181
spinosus, ix., 185
Amaryllideæ, vii., 14
Amazon river, xii., 96
stone, xiii., 162
Amber, ii., 13, 85, 87 ; ix., 150
history of, viii., 157
inclusions in, 156, 157
occurrence of, 157
source of, 157
fluorescent, 158, 162
Amblygonite, v., 80
Amboy clays of New Jersey, v., 136
x., 3
Amblyolepis setigera, vii., 11
Amblyopsis spelæus, i., 59–64
Amblystoma punctatum, vii., 225–256
Amelia county, Va., phosphorescent, fluorite, iii., 77, 100
Amendment, proposed, of by-laws, ix., 204
America ancient civilizations of, 120–124
denudation of, v., 77, 78
Amer. Assoc. Adv. of Science, vii., 1, 18, 43, 48, 129, 130, 134
vi., 129, 130, 136, 160, 162–166
at Springfield, xiv., 1
Amer. Antiq. Soc., vi., 140
Amer. Bureau of Mines, vii., 123
Amer. Cyclopædia, viii., 13
Amer. Folk Lore Society, x., 37
Amer. gems, viii., 160, 162
Amer. Geographical Society, vii., 17
viii., 175
Amer. Journal of Numismatics, vii., 79
Amer. Journal of Science, vi., 140 ; vii., 59, 64, 123
viii., 9, 13, 56, 132
ix., 26, 193, 197, 198
Amer. Museum of Natural History, vii., 80, 100, 136, 254, 255 ; viii., 8
Amer. Mus. Nat. History, Field Expedition, 1893, xiii., 122 ; xv., 67, 1895
Amer. Naturalist, vii., 66, 68, 136
Amer. Ornithologists' Union, vii., 255
Amer. pearls, viii., 162, 163
Amer. species of the genus Anemone, xi., 9
American Trias, v., 18, 19
Amethyst, ii., 89, 117 ; vi., 92, 113, 124 ; vii., 164, 223
for jewelry, viii., 161
phantom, viii., 12
Amia Calva, xv., 126
Amianthus, vi., 130
vii., 224
Amiens, France, flint implements at, iii., 80
Ammonia, v., 187
"process," v., 192
discovery of, vii., 198
Ammonites, ii., 11–94
Ammophila longifolia viii., 77
Amœba, ii., 79–82
Ampelideæ, vii., 9
Ampelopsis heptaphylla, ix., 10
Amperes and volts, ix., 137
Amphibia, vii., 257 ; xiii., 176
cranial nerves of, xii., 56
Amphibole, vii., 36, 57, 223 ; viii., 59
Amphibolite, viii., 54, 55
Amphilestes, xii., 187
Amphioxus, vii., 259; xii., 244
twins and multiple embryos of, xii., 17
Amphipleura pellucida, ii., 79
Amygdaloid, ix., 143
Anæsthesia, early experiments in, viii., 15, 16
Analcime, ii., 88
Analcite, vii., 232 ; ix., 143

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Analyses of brine, ix., 40
of dolomite, vii., 37-58
of Franklinite ores, ii., 26-35
of gas, 101, 102
of grains and cereals, x., 24
of marbles, vi., 23
of salt, vii., 124
of meteorite, v., 221
of Kiowa Co. meteorite, ix., 190
of Bridgewater " " 194
of Summit " " 196
of Colfax " " 197
of Winnebago " " 201
of Argentarsenickel " 152
sandstones, 118, 119
of the proceeds of combustion in locomotives, v., 144, 145
Anatomy of bird's wing, vii., 91-95
Ancient abundance of carbonic acid in atmosphere, iii., 91, 92
copper axe, iii., 15
drilling of rocks by corundum, iii., 105
fishes, armor of, iii., 53-55
mining excavations at Houghton, iii., 14
silver castings, iii., 15, 62, 63
stone implements, iii., 1, 7, 12
cities of Yucatan, vii., 45-48
temples, etc., of Yucatan, v., 169-178
civilizations of America, i., 120-124
civilization of America, iv., 47
glaciation in North America, ii., 155-159
astronomical instruments, xi., 206
inscription on a wall at Chatala, Tenn., xi., 26
shore lines, ix., 78
mounds at Inwood, ix., 199
Ancylopoda, xii., 95
Andalusite, ii., 42
Andromeda Parlatorii, xiii., 130
Andropogon saccharoides, ix., 182
vii., 14
scoparius, ix., 182
Anemone, American species of the genus, xi., 9
Anemone decapetala, vii., 7
heterophylla, vii., 7
patens, var. *Nuttalliana*, i., 8
Alpina, i., 8
Angiosperms, from Cretaceous, v., 133-137
from Dakota formation, v., 133
from Vancouver's Island, v., 133
Anglo Cymric score, vii., 43
Animal life in caves, i., 64-67
locomotion, methods of, i., 164-167
life, succession of, iii., 20
self defence, methods of, 53-55
mounds, x., 40
Ankerite, xi., 39
Annales de Geologie et de Palæontologie, vii., 128
Annals of Academy, vi., 66; vii., 60, 61, 64, 79, 89, 141
viii., 1, 41, 117, 127, 128, 152, 177
ix., 1, 2, 15, 108, 139
Annarachus, v., 53
Annual election, ii., 99; iv., 45; v., 162; ix., 108
erosion of continents, v., 78
growth rings in plants, iii., 88
Annual meeting, i., 124; ii., 95-100; 69th, iv., 45; 71st, vi., 108; viii., 125-129; ix., 104
Annulosa, v., 47
Anodon, viii., 163
Anodon excurvatus, vi., 113
Anomozamites majus, vii., 115
Schaumburgensis, vii., 115
Anonymos aquatica, ix., 12
Anorthite in meteorite, iv., 162
Anthracene, v., 193-196
Anthracite, iii., 7
in China, ii., 151
of Colorado, i., 8
with flattened concretions, iv., 44
of Pennsylvania, origin of, xiv., 100
Anthracotherium, xiii., 176
Anthony, R. A., elected resident member, xii., 220
Anthophyllite, vii., 57, 213, 214, 224
Anthraquinone, v., 192
Anthrocerina, xiv., 54
Anthropology, Psychology and Philology, Section organized, xv., 154
Antimony, native, from California, xiii., 139
Antique from Peru, viii., 15
Antiquity of man, iii., 7-12; ix., 83
Antrostomus carolinensis, x., 52
Ants, honey, of New Mexico, iii., 103
Anura, vii., 256

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Aparchites secunda. xiv., 136
Apatite, ii., 3, 14, 16, 147; v., 75, 232; vii., 38, 212, 213, 221; viii., 50; ix., 148
Apgar, DeWitt J., elected resident member, xi., 25
Aphanostephus humilis, vii., 10
Aphyllum multiflorum, vii., 12
Apium echinatum, vii., 10
Popei, 10
Aplodontia, new species from California, v., 179
Aplodontia major, v., 179
Aplome Garnets, iv., 42
Aplopappus croceus, viii., 80
Apophyllite, i., 129, 130; ii., 89; iv., 42; vii., 231; viii., 50, 57
Appalachian Valley, v., 215, 216, 217
Apparatus, distilling, xii., 54
Applications of electricity, x., 116
Aquamarine, ii., 117; ix., 151
from New York City, v., 25, 75; viii., 2, 7, 8, 152, 160; ix., 151
Aquilegia canadensis, i., 8
cerulea, 8
Ara militaris, v., 175
Arabia and Afghanistan, sonorous sand-hills, ii., 98, 99
Arabis Douglassii, ix., 8
rhomboidea bulbosa, ix., 8
rhomboidea purpurea, ix., 8
Arachnida, v., 49
Arachnodiscus, xii., 220
Aragonite, iii., 7, 17, 20; v., 229; vii., 221
breccia, viii., 44
coralloidal, viii., 45
fibrous from Morrisania, iv., 78
stalactitic, viii., 45
Aralia, iii., 47; v., 136
Araliopsis, xii., 236
Araucaria, vi., 128
Arca, ii., 11
Arc light, x., 103
lamp, x., 104
Archæan, of Blue Ridge, v., 219, 222
rocks, v., 219, 222, 223
strata, younger, v., 216, 233
" older, v., 220, 221
of Staten Island, vi., 15, 16
plant, vii., 89
series, vii., 39, 59, 138
time, vii., 153
in Essex county, N. Y., xiii., 216
Archæology, ii., 3, 106, 110
Archæological discoveries, vii., 139
of Greece, viii., 188
Archæophyton Newberryanum, vii., 89
Archipterigium, xii., 121
Archives de Biologie, 133
Archoplasm mass in Spermatogenesis of Lumbricus, xiii., 135
Arctic region, warm Tertiary climate in, iii., 94
Exploration of, i., 46–48
scenery, glimpses of, ix., 156
Arctostaphylos pungens, viii., 76
Ardea bahamensis, x., 54
Area of New York Island, vii., 49
Arenaria scabrella, viii., 78
Argemone, viii., 77
Mexicana, vii., 7
Argentarsenickel, ix., 152
analysis of, ix., 152
Argentiferous galena, x., 62
Argentite, iii., 38, 63
artificial, ix., 145
Argillyte, implements of, iii., 9
Arisæma dracontium, i., 182
Aristida, viii., 77
Aristolochiaceæ, vii., 13
Aristolochia longiflora, vii., 13
Arizona agatized woods, v., 9–11
minerals from, iii., 72
minerals, viii., 11, 14, 45, 46, 161
aragonite, 45
azurite, 12, 45
calco-malachite, 46
chaloocite, 45
cuprite, 13
malachite, 12, 45
native silver, 11
stromeyerite, 11
flora of, viii., 61, 81
new species from, viii., 65, 71, 72, 73
plants, enumeration of xiv., 21
pumice tuff, i., 52
silic. woods, vi., 165, 166
Arkansas, minerals from, iii., 17, 18
Arkose beneath the Palisades, N. J., ii., 117–120
Armor of ancient fishes, iii., 53–55
Aromatic series, new derivatives of, xiii., 161
Arrangement of atoms, v., 199
Arrow-heads near Trenton, N. J. iii., 8

Digitized by Google

of Oregon Indians, 63
of Palæolithic age, 81, 82
Arsenetted hydrogen, solidification of, v., 191
Arsenide of platinum, viii., 56
of silver, viii., 56
Art, aboriginal, viii., 116
Artemesia Mexicana, vii., 11
Artesian wells, vi., 77–91
" on New York Island, vii., 63, 64
" ix., 3
Arthropoda, v., 32
Arthrodiran fishes, relations of, xiii., 176
Articulata, v., 32
Artificial conversion of peat into coal, i., 75
formation of the honeycomb, iii., 107, 108
gems, ix., 155
origin of caves, ii., 3–6
ponds and lakes, viii., 117–125
Artiodactyl from Lower Miocene, xii., 50
Artionychia, xii., 96
Artionyx, xii., 95
Artistic uses of trance state, iii., 107
Arts, Winnebago, x., 39
Aruba, flora and fauna, ii., 151
terrestrial molluscs, 151
Asaphus platycephalus, xii., 237
gigas, ii., 3
Asbestos, v., 185–229 ; vii., 213-224
from Staten Island, 229
Asclepiadeæ, vii., 11
Asclepiodora decumbens, ix., 184
Asclepias subverticillata, ix., 181, 184
verticillata, ix., 181, 184
Ascyrum Crux-Andreæ, v., 217
Ashtabula salt well, ix., 41
Asphalt of Utah and Canada, ii., 50 viii., 26-28
pavements, viii., 43, 44
Aspicarpa hyssopifolia, vii., 8
Aspidium, v., 136
Aspidisea, ix., 34
Asplenites Ottonis, vii., 115.
Assets of the Academy, ix., 205
Aster adscendens, viii., 78
canescens, viii., 80
foliaceus, var. *Buskei*, viii., 79
pauciflorus, viii., 79
tanacetifolius, viii., 80
diffusus, ix., 11
lateriflorus (new), ix., 11
miser, ix., 11
multiflorus, vii., 10
Asteriation in garnet, v., 225, 226
Asteroides, v., 250, 251
intra-mercurial, 248
Astor, John Jacob, elected resident member, xiv., 48
Asterophyllites, iii., 46
Astragalus, viii., 77
Arisonicus, viii., 79
Greenei, viii., 80
Hosackiæ, viii., 80
Matthewsi, viii., 80
Busbyi, viii., 80
Mexicanus, ix., 183
Nuttallianus, vii., 9
Astrocladia, three species, xiv., 113
Astronomical drawings, Trubelow's, ii., 9
instruments, v., 261
literature, 261, 262
necrology, 262, 263
photographs, measuring apparatus for, xiv., 7
photographs, the reduction of, 124
progress for the year, viii., 13, 14
Astronomers, v., 262, 263
Astronomy of the earth, v., 234
progress in, 234
section of, x., 67
section officers elected, xiv., 154
photography applied to, i., 143–146
and physics section, xv., 1, 34, 63, 97, 124, 134, 147, 155
Atacamite from Globe, Arizona, xiii., 184
Athyris subtilita, v., 122
Atlantic coastal plain strata, dislocations in, xiv., 8
ocean (north) age of, v., 77–79
Atlantis, its possible location, i., 24
Atmosphere, carbonic acid in, iii., 40, 41, 91, 92
circulation of, 61
darkened by smoke, 60, 61
of Pittsburg, acidity of, 65, 66
of the sun, v., 241
height of, xi., 40
Atmospheric agencies, erosion by, v., 78
phenomena, yellow clay, i., 1
Atomic energy, v., 183

Digitized by Google

structure, 184
theory, 182, 198, 199
weights, 182, 183
Atriplex, viii., 77
Atrypa reticularis, i., 57; iv., 33; viii., 180
Attendance at meetings, vii., 129
Aturia Vanuxemi, ii., 12
Aubrey limestone, fissure in, xii., 77
Audibertia Mearusii, viii., 71
Audubon monument committee, 63
report of, 64
statements, 65
resolution, 65
monument, vi., 163, 164; vii., 1, 116–130; viii., 128; ix., 109
committee, xii., 2–125
John James, monument to, xii., 217
life and services of, xiii., 43
monument, acceptance of, xiii., 37
presentation of, xiii., 30
committee report of, xiii., 23–151
treasurer's account of, xiii., 58
publication fund, xiii., 63
Auerlite, viii., 8–22
Augen-gneiss, Bedford, N. Y., xv., 185
Augite, vii., 215–223
Augite-porphyrite, xiv., 215
Auriferous deposit in Buckingham county, Va., xiii., 122
Aurora Borealis, i., 158
of Feb. 13, 1893, xi., 105
" 23, 1894, xiii., 171
Austria, ozokerite deposits, ii., 43–48
Australia, tin of, viii., 147
Aulostoma, funnels and vesicles of, xiii., 206
Autunite, vii., 218–237
Avalonia Acadica, xiv., 140
Avefauna, Bahaman, x., 54
Avicenna, x., 6–15
Axles (car), cause of breaking, v., 149–151
Axis of earth, v., 235; vii., 147
Axolote, xiii., 136, 139
Azoic rock, Staten Island, x., 228
Azurite from Arizona, x., 9; vii., 194–217; viii., 12–45; ix, 431

Baccharis Texana, ix., 181
Bacillus Lachis Erythrogenes, xiv., 96
Bacteria, development of, ii., 113, 114; v., 16, 117; vi., 40
notes on, 148
of New York, xiv., 80
variations in biological characters of two species, xiv., 96
Bacteriology, methods of research in, ix., 139
Baculites, ii., 11, 94; v., 133
Bahamas, x., 3
formation of, x., 21
geology of, x., 4
bank, great, x., 4
little, x., 4
Bahaman birds, x., 52
avefauna, x., 54
Bahia oppositifolia, viii., 77, 78
Baird, Spencer F., death of, vii., 1
Bajera munsteriana, vi., 126
Balcony Falls, Va., v., 219
Ballast, railway, v., 151
Balloons, use of in Arctic, i., 47, 48
Baltic amber, ii., 85, 86
amber of, viii., 157
singing beaches of, iii., 97, 98
Banana holes, x., 12
Banca, tin of, viii., 149
Bank, Carsos, x., 4
Banks, Sir Joseph, viii., 24
Barcenium, v., 200
Barite, viii., 17
Barium nitrate, vii., 69
Barnacles, viii., 170
Base of the Cambrian rocks, xiv., 104
Basalt, ii., 3–6; i., 4, 5
in Palestine, vii., 175, 176, 177
tuff, 52
containing native iron, iii., 104
Basaltic boulder from Woodbridge, Conn., iv., 25
boulders, xiii., 161
Basanite, vii., 223
Basic effusives, New Brunswick, xiv., 196
Bassasseachic, visit to Falls of, iii., 148
Bathyurus caudatus, vi., 2
Bats in caves, i., 64–67
Battle of termites, viii., 96, 97
Bauhinia, v., 136
Bauxite mines of Georgia and Alabama, xv., 143
Bayne, S. G., elected resident member, xiii., 171
Beach, Coronado, x., 31
Redondo, x., 31

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Beach, Frederick C., elected member, xv., 147
Beach, singing, at Manchester, ii., 147, 148
Beaver Pond and cut sticks found in it, xiii., 177
Pond at Plainfield, N. H., xiii., 115
Bees and other hoarding insects, iii., 103
Beet sugar, cultivation of, iii., 5, 6
Behavior of steam in steam-engine cylinder, i., 111–114
Belemnitella mucronata, ii., 10
Belgium, human remains in, viii., 132–135
quaternary, fauna of, viii., 132–134
Bell, Dr. Clark, elected resident member, xi., 25
Bell mountain of the, viii., 182, 183
slope, Seitzen's, ix., 22
Bolton's, ix.. 23
Benzine, v., 195
group, 196
ring, 195
Benzoic acid, v., 195
Berberidaceæ, vii., 7
Berberis aquifolium, i., 8
repens, viii., 79
trifoliata, ii., 92; vii., 7
Bergen Hill, N. J., indurated shales at iii., 7
Bergeronia articephalis, xiv., 146
elegans, xiv., 146
Berlandiera lyrata, ix., 184
Bertrandite, viii., 11, 12
Beryl, i., 101–105; ii., 25; iii., 2, 38–107; vii., 48, 140, 212, 224–228; viii., 2, 7, 8, 12, 152–160
blue, from Mt. Anteros, Colorado, iv., 80
from New York Island, v., 75, 223
from Stoneham, Maine, v., 132
from Connecticut, vi., 40
from New York, vi., 130
Berzelian notation, ii., 105, 106
Bessemer steel, v., 147, 148–152
Beyrichona papilio, tenea, planata, xiv., 134
triangula, rotundata, ovata, xiv., 135, 136
Bible times, chemical arts in, xi., 120
Bibliographical compilation, xv., 39
Bibliography of natural history, etc., x., 71
of chemistry, xi., 131
Biceps flexor cubiti, morphology and variations, xiii., 132
insertion of, xiii., 234
morphology of, xiv., 230
origin of, xiv., 234
Bignonia tomentosa, ix., 12
Bill of Hudsonian Godwit, ix., 30
Bilobites, iv., 78
Binocular perspective, i., 9–15
Biological Section, xv., 66, 148
Biotite, iii., 49; v., 232; vii., 212–227; viii., 50–54
altered from Franklin Furnace, xiii., 181
Bioplasson doctrine, i., 31–46
structure of, ii., 79–84
Birds, desc. of (title), v., 111, 139
flight of, xii., 20, 21, 75–78, 80–87, 89–100
Bird life in the West Indies, Origin of, xii., 50
Birds, new species, i., 176; ii., 151
supposed new species of, iv., 34
Birmingham, England, viii., 18, 23, 24
philosophers, viii, 194–211
Bismuth, in San Juan Mts., v., 128
Bitterns, ix., 43
Bitumen of Dead Sea, vii., 177; viii., 26, 28
Bituminous shales, carbon in, ii., 110–111
Bland, Mr. Thomas, death of, v., 29, 278
Blende, ii., 90-94
Blind fish in caves, i., 59, 64–67
Bliss, Charles B., elected member, xv., 147
Block Island, geology of, xv., 16
Blocks of conglomerate, separation of, iii., 23, 29, 30
Blood corpuscle, structure of, ii., 80–82
Blue-beach (volcanic breccia) of Virgin Is., W. I., i., 21
Bluestone, durability of, ii., 126, 136
Boas, Dr. Franz, elected member, xv., 97
Boat-racing, vi., 114–118.
Bodley, Dr. R. L., death of, viii., 9
Boerhaavia linearifolia, ix., 185

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Bog iron ore, vii., 219
Boiling holes, x., 12
Boletus destructor, v., 111
Bolivia, flora of, x., 115
Bolometers, new method of making, xiii., 171
Bolton, H. Carrington, elected President, xii., 128
Bombinator, xii., 245
Bombycine moths, xii., 138
Bone-cave of Gailenseuth, ii., 37
Bone-oil, ii., 63
Boomerang problem, xii., 77
Booth, Jas. Curtis, decease of, vii., 139
Boragineæ, vii., 12
Bornholm, Denmark, singing beach, iii., 97
Bornite, vii., 217; viii., 59
Borislau, ozokerite mines, ii., 43-48
Bos primigenius, viii., 133
Botanical collection of the Academy, iii., 32
Botany, contributions to Texan, ix., 181
of Texas and Chihuahua, ii., 66, 90, 94
Botsfordia pulchra, xiv., 115
Bouchetia anomala, vii., 12
erecta, vii., 12
Boulders in Great Hudson Valley, iii., 24-26
of rock crystal from Alaska, 81
of field of rocks, vii., 16
basaltic, discovery of, in Vermont, xiii., 161
basaltic, petrography of, xiii., 161
Bournonite, vii., 217
Bouteloua hirsuta, vii., 14
racemosa, 14
hirsuta, ix., 182
Texana, 182
trifida, 182
Bouteloua, viii., 77
Bowenite, viii., 162
Bowlesia lobata, vii., 10
Brachiopods, vii., 2, 3
Brachiopoda of Protolenus fauna, xiv., 113
Brachymetopus, vii., 250
Brachyphyllum, v., 136
Brachyphyllum foliosum, vi., 126
gracile, 126
Brachyris Euthamiæ, vii., 10
Brauner, Bohuslav, Ph.D., elected corresponding member, xiv., 48
Brazil turba, i., 76
minerals from, iii., 21, 34, 107
Brenham township, Kan., map of, ix., 187
Brevoort collection, ix., 3
J. Carson, memorial, vii., 78-80
Bridgham, Samuel W., elected resident member, xiv., 154
Bridge at Pittsburg, decay of, iii., 65, 66
construction, vi., 148-160
historic, vi., 148-160
Bridgeton, N. J., fossil plants from, iv., 31
Bridgewater meteorite, ix., 194
analysis of, ix., 195
polished section of, ix., 195
Brilliant colors of red sunsets, iii., 60-61, 64-65
Brine, analysis of, ix., 40
Bristol, Charles L., elected resident member, xiv., 65
Bristol, C. L., elected Sectional Secretary, xv., 66
British America, moraines in, viii., 164
Assoc., Oxford meeting, xiv., 45
Jour. of Photography, vii., 106
Britton, N. L., elected Recording Secretary, xii., 128
Brockway, F. J., elected resident member, xiii., 151
Brodiæa, viii., 77
Bromine, vii., 38
Bronzite, vi , 76
Brooklyn Acad., vii., 113
Aqueduct, vi., 82
buildings of, ii., 67-71
Institute, vii., 237
Brown hematite in southwest Virginia, i., 162, 163
Brown's Park Beds, Utah, stratigraphical relations of, xv., 252
Brownstone, durability of, ii., 122-124, 136
Brown tourmaline, vii., 230
Bruce's American Mineralogical Journal, xi., 57
Bryanthus, i., 6
Bryograptus (?) *retroflexus* (?), xiv., 271
lentus, xiv., 270

Digitized by Google

patens, xiv., 268
spinosus, xiv., 269
horizon and locality, xiv., 269
lentus, horizon and locality, xiv., 270
Bryozoa, ii., 85
Buchloë dactyloides, i., 4; ix., 182
Buenos Ayres, flora and fauna, ii., 151
terrestrial molluscs, 152–154
Buffalo remains at Plainfield, N. J., xii., 24
Bufo lentiginosus, xii., 244
Building-fund, old, list of subscribers, iii., 109–111
Building-stone, decay of, ii., 67–79
used in N. Y. City, iv., 57, 77
Builders, Mound, x., 42
Bulimulus elongatus, ii., 151, 152
multilineatus, ii., 152, 153
Bulimus lubricus, iii., 21
Bulla v., 53
Bulletin of the Torrey Botanical Club, ix., 6
Bulletin of the National Institute, ix., 132
Bunsen battery, new form of, x., 114
Burr, W. H., elected resident member, xiii., 23
Business meetings, ix , 1, 26, 55, 74, 98, 104, 127, 137, 157, 204
miscellaneous, ix., 36, 84, 140
Butio borealis, vii., 97
lineatus, vii., 20
Butler, Nicholas Murrey, and others petition for membership to form a Section to deal with scientific investigations in Philosophy and Philology, xv., 70
By-laws, vi., 1, 2, 58, 66
change of (see Contents), vii.
amendment to, ix., 204; x., 55
amendments of, adopted, xiii., 1
Byssolite, iv., 42
penetrating quartz, v., 214; vii., 224; viii., 59, 161

Cabin Creek meteor, vi., 141–146, 166
Cabin Creek meteorite, viii., 186
Cabomba, iii., 43
Cachalong, vi., 112
Cacoxenite, xii., 70
Cacteæ, vii., 10
Cadmium borotungstate, vii., 31
Cælacanthus elegans, xiii., 131
Caen limestone, durability, ii., 128
Cælosterus ferox, vi., 137, 138
Caicos Bank, x., 4
Calamine, ix., 148
Calc spar from Weehawken, N. J., i., 129
Calcareous tufa at Nat. Bridge, v., 218
Calceocrinidæ, revision of, viii., 152
Calciferous epoch, v., 216
in Essex Co., N. Y., xiii., 221
Rocks of Ticonderoga, xiii., 20
sand rock, vii , 5
Calcite, ii., 64, 89; iii., 7, 17
curious crystals from Colorado, iii., 19, 20
enclosing copper, iv., 47
at Cranberry Mine, v., 221
with Celestite, 213; vi., 91, 92, 113, 130; vii., 23, 35, 37, 56, 57, 62, 215, 217, 219, 221; viii., 50, 54, 57, 58, 60
green, viii., 45; ix., 43
Calcium, vii., 220
chloride, v., 186
in Comets, v., 254
in Carbonate. vii., 36
di-malate from sugar maple, i., 167
Calco-malachite, viii., 46
Calculation of star places, etc., x., 86
California, minerals from, iii., 72; viii., 22
petroleum in, viii., 25
silicified wood from, viii., 29, 30
tin from, viii., 150
musical sand in, ix., 31
Callichelidon cyaneoviridis, x., 52
Callirrhoë involucrata, ix., 183
palmata (new), ix., 183
pedata, vii., 8; ix., 183
Callognathus Newberryi, xii., 39
Callograptus, Hall, xiv., 271
horizon and locality, xiv., 271
Calls to domestic animals, vii., 120–122
Calochortus, viii., 77
Gunnisoni, i., 8
Nuttali, i., 8
Calophanes linearis, vii., 12; ix., 185
Catopterus, v., 18
Calotermes, ix., 158
Marginipennis, viii., 86; ix., 161

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Caltha dentata, ix., 6
flabellifolia (new), ix., 6
palustris flabellifolia, ix., 6
palustris Sibirica, ix.,
radicans, ix., 7
Caltrops from western Pennsylvania, iv., 40
Calymene, xii., 238
Calyptrate Muscidæ, xi., 131
Cambarus pellucidus, i., 59, 64
Cambrian formation, vi., 113
phosphate nodules from, xii., 108
(Potsdam) Quartzite in Essex Co., N. Y., xiii., 219
rocks of N. Amer., viii., 176
of S. E. Penn., viii., 48, 50
Strata near St. John, N. B., xiv., 20
Cameos, process of cutting, iii., 105
Campanula Scheuchzerii, viii., 80
Camptonite dikes near Thetford, Vt., xiii., 164
Canada, minerals from, iii., 1, 2, 7
balsam, v., 231
Canal survey, Van Rensselaer, xi., 45
system of China, viii., 165
Cape of Good Hope Observatory, xv., 63
Capsicum faccatum, vii , 12
Car axles, breaking of, v., 149, 151
Carbazostyril, v., 196
Carbon minerals, origin of, i., 109–111
dioxide in cavities of quartz, 133–136
dioxide, exhalation in Utah, 170–172
in bituminous shales, ii., 110–111; v., 186, 195
compounds, v., 195, 197
in sun, v., 245
monoxide, v., 186, 187, 188, 190
as primary matter, v., 184
weight of atom of, v., 183; vii., 6, 36, 37, 217
Carbonate iron-ore of coal measures, ii., 14–15
Carbonic acid, v., 190
liquid, vi., 35; vii., 37
in the atmosphere, iii., 40–41
ancient abundance in atmosphere, 91–92
in natural waters, iii., 42
Carboniferous area of Newport, R. I., iv., 76
strata in Colorado, v., 122, 126
fishes, vi., 137, 138
limestone, vi., 137, 138
fishes, vii., 165
limestone, vii., 165, 247
trilobites, vii., 247
period, equable climate, iii., 94
sharks, armor of, iii., 54
Carborundum, Notes on, xiv., 67
Carcharodon, i., 180
Cardamine bulbosa purpurea, ix , 8
Douglassii (new), ix., 8
flexuosa (new), ix., 9
hirsuta Virginica, ix., 9
hirsuta sylvatica, ix., 9
rhomboidea purpurea, ix., 8
rotundifolia, ix., 8
sylvatica, ix., 9
Virginica, ix., 9
linearifoba, vii., 11
Cardiospermum, ii., 92
Cardita granulata, ix., 88
Carditamera arata, ix., 88
Cardium, ii., 11
Cardium speciosum, ix., 31
sublineatum, ix., 88
Caribbean Sea, waterspouts in, iii., 3
Caribs in North America, ii., 142
Cairo, street scenes in, xi., 73
"Carlisle" stone, v., 12, 13, 61, 62
Carnelian, iii., 62
Carpinus, iv., 31
Carpites, xii.. 38
Carpolithes, xii., 38
Carrara marble, durability, ii, 129–133
Carum Gairdneri, viii., 80
Carved sandstone head from Staten Island, iii., 81
Cascade Mountains, glaciation in, ii., 155
Casey, Thomas L., x., 53
elected Corresponding Secretary, xii., 128
gift to the publication fund, xii., 40
Cassia pumilio, vii., 9
Rœmeriana, ix., 184
Cassiopeiæ, parallaxes of stars in, xii., 56
Cassiterite, viii., 136–151
Castalia Leibergii, ix., 8

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pygmæa, ix., 7
odorata minor, ix., 7
tetragona Georgi (new), ix., 7
Castilleia, viii., 77
gloriosa, viii., 71
Castings, ancient silver, iii., 15, 62, 63
Castoroides, iii., 14
Casts, screw-like, in Chemung sandstones, iii., 33-34
Caswellite from Franklin Furnace, N. J., xiii., 181
Catacombs, Egyptian, v., 120
Catalogue of N. A. Paleozoic Crustacea, viii., 152
American Minerals, vii., 211
Chemical periodicals, iv, 93
stars, v., 257
Catalpa, v., 119
speciosa, iii., 107
Catalytic phenomena, v., 185
Catania, Sicily, amber, ii., 85
Catfish of South America, xiv., 21
Catopteurs anguiliformis, vi., 127
gracilis, vi., 127
ornatus, vi., 127
parvulus, vi., 127
Redfieldii, vi., 127
Catorce meteorite, v., 227
Catseye, ii., 26, 42
chrysoberyl, v., 131
Catskill Mountains, N. Y., erosion and glaciation, i., 24-31
group, ii., 8; v., 281
Cattell, J. McK., elected resident member, xiii., 155.
Cauchy's Formula for Metallic Reflection, application of, to Platinum, xiv., 175
Cause of chemical reaction, xv., 61
the tides, viii., 187
Causes of red sunsets, iii., 60, 61, 64, 65
Cave-fauna of Belgium, viii., 132, 134
Cave, Mammoth, of Kentucky, i., 59; 66
Caves, ix., 10
animal life in, ix., 64-67
human bones in, ix., 11; ii., 36-41
Staffa, ii., 3-6
Cavities in quartz from Montclair, N. J., xiii., 184
Cay, Salt, x., 4
Cays north of New Providence, formation of, x., 19
Ceanothus, iv., 31
ovalus, ix., 183
Cedar Keys, Fla., mounds at, vii., 164, 165
Cedronella, xiii., 98
Celastrus scandens, xii., 38
Celestite from Texas, v., 213
Celastrophyllum, v., 136
Celastrineæ, vii., 8
Celastrus, v., 136
Cellis occidentalis, ii., 92
Cell-doctrine, i., 31-46
Cell-structure of Wood, v., 113, 119
Cells, united action of, i., 44, 45
Celt of meteoric iron, v., 227
Cemeteries, decay of stone in, ii., 124, 129, 133-135
Cenoplacentalia, xiii., 175-234
Centaurea Americana, ix., 181, 184
Center, Robert, elected resident member, xiv., 154
Century Magazine, vii., 254
Cerastium viii., 78
Ceratodus, ii., 146; xii., 123
Ceratophyllum demensum, iii., 43
Ceratops, ix., 31
Ceraurus, xii., 238
Cercio occidentalis, ix., 184
reniformis, 184
Cercocarpus parvifolius, viii., 76
Ceresine from ozokerite, ii., 48
Cerillos coal fields near Santa Fé, New Mexico, 105
introduction, 106
geological structure of the area, 107
the eruptive rocks, 108
the Laramie, 110
the White Ash coal bed, 110
the Boyle mine, 111
the Lucas mine, 113
the Cunningham mine, 113
the White Ash mine, 114
the Coking seam, 115
the Cook-White coal bed, 116
characteristics of the coals, 117
chemical composition of the white-ash bed, 117
chemical composition of the Cook-White bed, 119
cause of the metamorphism of the coal, 120

Digitized by Google

Cerium, vii., 220–226
Cerulius vastator, v., 111
Cervalces, xiii., 180
Cervus Canadensis, xiii., 180
Cestrum diurnum, ix., 185
Cetacea, vii., 254
Ceylon, gems from, iii., 17–107
Chabazite, iii., 18; vii., 62, 214–232; viii., 54; ix., 144
Chærophyllum procumbens, vii., 10
Chætetes milli-poraceus, vii., 247
Chætodontidæ, vi., 77
Chætura peregrinator, v., 55
Chalcedony, ii., 117; v, 133; vi., 122–124
in Syria, vii., 174; viii., 16, 161, 162
park in Arizona, v., 9; ix., 142
Chalchihuitl, viii., 162
Chalcocite, ix., 140
Chalcophanite, ii., 64
Chalcopyrite, ii., 25–149; iii., 23; iv., 41
in epidote, v., 121; vii., 62, 217–222; viii., 56, 57, 140–144
Chaldean account of creation, ii., 107–110
Cosmogony, vii., 143
Chladni's figures, xiv., 70
Chalicotherium, xii., 95
Chalk Cliffs of Palestine, vii., 170–174
Challis, Idaho, mines at, i., 5
volcanic tuff, i., 49
Chamæsaracha sordida, vii., 12
Chamberlin, Mr. B. B., death of, viii., 7, 8–13
memorial of, viii., 46
Champlain clays, i., 30; ii., 2
deposits, iii., 10–23
elevation of, iii., 95
Change in our climate, ix., 206
in position of the earth's axis, iii., 89, 90–95
of by-laws (see contents) vii.,
Changes on the lunar surface, xi., 42
Channel of Mississippi river, vii., 164
Chapin, Chester W., elected resident member, xiv., 220
Chapman, Frank M., elected resident member, x., 45
Chaptalia nutans, vii., 11
Characinidæ of South America, xiv., 21
Characters of new species of birds, etc., v., 55
Charmouth, England, erosion in valley, i., 27, 28
Charter, Constitution and By-laws of Academy, viii., 153–168
of the Academy, viii., 189
Chazy in Essex Co., N. Y., xiii., 221
rocks at Chazy, 22
Isle LaMotte, 22
Highgate Springs, 22
Basin Harbor, 23
Plattsburgh, 21
Cheeseman, Dr. Timothy, elected resident member, xiii., 234
Cheiropterygium, xii., 121
Cheirolepis Munsteri, vi., 126
Chemical affinity, v., 185–187
discoveries, v., 193–197, 199
elements, v., 181-183, 200, 244
formulæ, v., 195, 197–199
literature, v., 201, 202
nomenclature, v., 179, 180–193
phenomena, v., 199
reactions, speed of, v., 188
heat, v., 189
societies, v., 180–200
analysis of salt, vii., 124
discoveries, v., 198–203
arts in Bible times, xi., 120
literature, an international index to, xiii., 2
notation, history of, ii., 53–57, 102–106
periodicals, catalogue of, iv., 36
purification of water, vi., 52–54
terms, pronunciation of, xii., 40
Chemistry, late discoveries in, v., 193, 197–199
physiological, v., 198
recent progress in, v., 179–202
relation with physics, v., 189, 190
sanitary, v., 198
bibliography of, xi., 131
progress of, xii., 128
Chemists, number, v., 180–200
Chemung, v., 281
groups in the Catskills, v., 28
fossil fishes, iii., 32
screw-like casts, 33, 34
vii., 178, 179
Chenopodium album, iii., 88
leptophyllum, ix., 185
Chert, vii., 223

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Cherts, of Missouri, microscopic structure of, xiv., 63
Chesapeake bay, singing beaches on, iii., 73, 74
Chester, Prof. Albert H., elected resident member, xi., 25
Chihuahua, botany and geology, ii., 66, 90–95
Chili, copper axe from, iii., 15
Chimæra, ii., 145
Chimneys, ventilating, i., 67–70
China, canals of, viii., 165
internal trade of, viii., 165, 166
Mesozoic coal-plants, ii., 151
railway problem in, xi., 44–156
Chirigni, gold images, iii., 63
Chlorastrolite, viii., 162
Chlorate of potassium, v., 215
Chloride of lime, v., 193
Chlorine, v., 186
solidification of, 191
Chloris cucullata, vii, 14
Chlorite, v., 75, 76
coating quartz, 214
vii., 215, 221, 222, 231, 233
viii., 53
from Wehawken, N. J., i., 131
iii., 1, 50
from Morrisania, N. Y., iv., 78
Chloroform, discovery of, xi., 149
Chlorophane, phosphorescence of, iii., 77, 100
Chlorothorite, viii., 185
Chordeumidæ of North America, xii., 242
Chondrophyllum orbiculatum, xii., 35
Chondropoma Tortolense, ii, 150
Chonophyllum Sedaliense, vii, 247
Choteau limestones, vii., 246
Chromite, vii., 219; viii., 49
in meteorite, vi., 76, 162
Chromium in iron ores, ii., 17
Chromosphere of sun, iv., 244
Chrysoberyl, i., 2; ii., 42, 64
cat's-eye, v., 131; vii., 220, 237
Chrysocolla, viii., 59; ix., 143
Chrysopsis villosa, vii, 10
Chrysotis canifrons, n. sp., ii, 151
Chrysotile, vii., 233
Ci-bo-hi-kan, x., 41
Cicada, v., 121
Cichlidæ, revision of North American, xiii., 110
Cicuta, iii., 39
Ciliata Chlamydodon, ix., 34
Cimicifuga racemosa, viii., 76
Cinicus, viii., 80
Cinnabar, viii., 22
Cinnamomum, xii., 35
Cinnamon-stone, v., 75
Cionella Gloquei, ii, 152
Circleville, Ohio, cloth from mound at, iv., 5
Circulation of the atmosphere, iii., 61
Cirripedes, occurrence of, in Cambrian rocks, xv., 144
Cisluta, ii., 151–153
concepta, n. sp., ii., 150
maculata, n sp., ii., 152
Raveni, ii., 151
Cities, pavement of, viii., 41–44
Citrine, viii., 161, 162
Civilization of America, ancient, i., 120–124
Cladium effusum, ix., 185
Cladodus Kepleri, vii., 178, 179
Cladodus, xii., 123
Cladoselache, xii., 124
Newberryi, n. sp., xiii., 115
Clathropteris platyphylla, v., 18; vi., 126
Clay of the mud-geysers, iii., 7
Claystone, vii., 16
Clays, Amboy, x., 41
Amboy, New York State, xii., 40
Clay of N. Y. State, Microscopic Organisms in, xiii., 165
of the Hudson river valley, xi., 133
Classified list of N. Y. Min., vii., 217
Cleavage of rocks, vii., 32–34
Clematis Drummondii, ix., 181
Pitcheri, ix., 183
Cleome integrifolia, i., 8
lutea, 1., 8
Clevelandite, vii., 228
Cleopatra's needle, v., 67
Clepsine, Funnels and Vesicles of, xiii., 206
Clerc, L., elected corresponding member, xi., 25
Cliff dwellings, x., 44
Cliftonite, vii., 6
Climate, alternations of geological, iii., 94–96
aridity near Rio Grande, ii., 90, 91
of Spitzbergen, iii., 85–87
Clintonite, ii., 26
Clinton iron-ore, ii., 15, 16

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Clocks, winding apparatus, v., 153–157
error of, v., 153, 154
Clenograptus, Hall, 1843, xiv., 265
horizon and locality, ii., 267
Cloth from mound at Circleville, Ohio, iv., 5
Coahuila meteorite, v., 231
Coal, anthracite, from Anthracite creek, Col., i., 8
bituminous, in Texas, i., 15, 16
bituminous, in Arctic region, i., 48
bituminous, in Virginia, i., 160–162
coking from Crested Butte., Col., i., 7
conversion of peat into, i., 75
origin of, i., 71, 72, 109–111
in Texas, ii., 94
physical conditions in formation of, ii., 50
plants from China, ii., 151
Measures, carbonates, ii., 14, 15
flora, ii., 56
Massilon, Ohio, ii., 87
combustion in locomotives, v., 144–146, 150
tar products, v., 194, 195
in Syria, vii., 174
measures in Md., vii., 246–250
Coastal sub-group, xiv., 192
Cobalt in meteorite, vi., 92
Cobaltous chloride, v., 186
Cocaine, v., 197, 198
Coccolite, vii., 223
Coccosteids, new forms of, xiii., 176
Coccosteus, xii., 71–187; ii., 144; iii., 20; v., 26–28
Cocculus diversifolius, ix., 181
Coccyzus minor maynardi, x., 52
Codonites campanulatus, vii., 247
Cœlenterata, v., 55
Cœlosterus ferox, vii., 165
Colburg, Prussia, "singing beach," iii., 98
Coldbrook, sub-group, xiv., 192
Coldenia canescens, vii., 12; ix., 185
Coleoides typicalis, xiv., 129
Coleopterological Notices, No. i., No. ix., 2; No. iv., xi., 125
Coleps, ix., 34
Colfax meteorite, ix., 197
meteorite, analysis of, ix., 198
Collecting specimens, x., 83
Collection, ichthyological, ix., 3
Collectors of N.Y. minerals, vii., 211, 212
Colorado, fossil fishes near Green River, iii., 131
fossil insects at Florissant, 13
" palm " " iii., 77
" plants " Golden, iii., 77
minerals from, iii., 13
siliceous sinter, iii., 6, 7
silicified wood, iii., 6, 7
San Juan Mts., v., 121–130
silver product of, v., 129
forest vegetation, i., 8
mining, i., 7
(title), vii., 44
minerals from, viii., 12
moraines in, viii., 164
oil deposits in, viii., 25–28
Grand Cañon of the, ix., 128
Coloration of marble, iii., 101
Colored clays, ix., 45
marbles, ix., 95
marbles of Lake Champlain, iii., 100
Color photography, xiv., 185
of images, difference in., xiv., 178
of Triassic rocks, vi., 125
standard, method of defining, xiii., 170
Colubrina Texensis, vii., 9
Columbia College collecting party, xiv., 101
museums, iv., 35
centennial, vi., 113,129
vii., 86, 129, 133
Columbia Chemical society, memoirs of, xi., 57
Columbidæ, i., 176; iv., 34
Columbite, ii., 42
vii., 48, 219; ix., 150
Columbium, v., 200
Columnar Trap, Orange, N. J., iv., 4
Combustion in locomotives, v., 144–146, 150
Comesium, v., 200
Comet, Gould's observations on, ii., 18–23
Comets, v., 246, 253–256
Comet, history of Lexell's, x., 114
of 1892, observations on, xi., 120
Holmes', xii., 48
discovered by photography, xii., 26

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Commelinaceæ, vii., 14
Commelina nudiflora, vii., 14
Virginica, *vii.*, 14
Commercial oil-testing, xi., 126
Commission, government, for testing iron and steel, i., 149
of annual Reception, xiv., 65
Audubon monument, xiv., 91
Committee, conference on union of local societies, x., 112
for election of sectional officers. x., 39
on completion of volumes of State Geological Survey, i., 85, 99,100
on memorial of Dr. J. N. Draper, i., 77, 105–108
on memorial of Dr. A. L. Holley, i., 108, 147–149
reports, v., 1, 164, 278
on library, ix., 127
on nominations, ix., 127
on publications, ix., 1, 107, 108, 127
special, xiv., 4, 37, 70, 109
on revision of the by-laws, xiv., 39
appointed, iii., 37, 71,80, 106
report of, iii., 12, 50–60, 70
standing, x., 103
Comparison of the theories of mountain making, forces and ice action, xiv., 17
Composite coronography, viii., 153
Compositæ, vii., 10
Composition of matter, vii., 259
Conception of species as modified by evolution, xiii., 132
Concretions of pyrite, ii., 138, 139
Condenser for water, analysis, xii., 54
Condition of interior of the earth, xix, 72
Conglomerate in Page Valley, Va., v., 217
Conglomerate, Shawangunk, joints in, iii., 23
separation of blocks of, iii., 29-30
Conifer, microscopic structure of, iii., 87
Coniferæ, iii., 46
Conifers in Cretaceous, v., 134–136
Connecticut, minerals from, iii., 77
Connellite, viii., 9
Conocardium. iv., 78
Conocarpus, x., 6
erectus, x., 16
Conocoryphe, not in Protolenus Fauna, xiv., 150
special to Lower Paradoxides Beds, xiv., 150
Constitution of the Academy, iii., 153–168
supplement, x., 153–168
Construction of maps of U. S., viii., 21
"Contact actions" v., 185
Contamination of water, viii., 117–125
Continents, erosion of, x., 78
Continuous eyelobes, trilobites with, xiv., 139
Contributions to Audubon monument, vii., 117
to invertebrate palæontology, x., 4
to Texan botany. ix., 181
of organic chemistry to modern science, xi., 107
Conulus, ii., 152
Conversion of electricity into light, v., 97–102
into power, v., 102–110
heat into electricity, v., 90–97
Convolvulaceæ, vii., 12
Convolvulus hermannioides, vii., 12
Cookeite, v., 80
Cook, Prof. George H., death of, ix., 4
memorial, ix., 75
Cooper, Mr. Wm., viii., 44
Cooperia Drummondi, vii., 14
Copernicus, index to, x., 87
Copper at Abiquiu, New Mexico, i., 20
gray, Ulay Mines, Col., i., 3
products, holding silver and tellurium regions in Northern Texas, i., 15-20
region in Indian Territory, i., 19–21
axe from Chili, iii., 15
carbonate. iii., 2
native. iii., 2. 19
ores of Triassic age, iii., 18, 19
series of Lake Superior, iii., 143,
silicate. iii., 2
sulphide, iii., 1, 2, 18, 19
carbonate, ii., 150
native, ii., 150
silicate, ii., 150
sulphuret, ii., 150

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implements, iv., 47
instruments from Houghton, Mich, iv., 76
in pyrites, v., 192
in San Juan mts., v., 128
salts of, v., 215
sulphate of, v., 215; vii., 217
in Syria, vii., 172, 174
alum, vii., 220
ores, ix., 150
pseudomorphs, 140; x., 59
Copperas in Staten Island, vi., 16
Corals, fossil, vii., 247
growth of, vii., 253
in N. Y. drift, vii., 213
Coral reefs, vi., 32
Cordaites, iii., 49
Corchorus pilobolus, ix., 181
Coreopsis cardaminefolia, vii., 11
trifida, ix., 482
Corn, Indian, xii., 8
Correspondences of Genesis and Science, vii., 151
Corresponding members, election of, iii., 1, 18, 32, 37, 48, 72.
members, list, ii., 126–137
members, election of, vii., 120, 140, 145
members, number of, vii., 131
members, vii., 219
number, vii., 127
members, x., supplement
Secretary's report, x., 133
Secretary, report of, viii., 127
Secretary, report, iii., 68
Secretary, vii., 131, 133
report, vii., 131, 245
Secretary, report of, ix., 105
Societies, ix., 127
Corylus Americana, ix., 31
rostrata, ix., 31
Coscinodiscus, xii., 120
Cosmogony of Genesis, vii., 141–154
Cosmopolitan time, vii., 91–94
Cossina (Microlepidoptera), xiv. 53.
Costa Rica, sounds on beach of, iii., 76
Coster, C. H., elected resident member, xiv., 220
Cothurina, ix., 34
Cotton in Brazil, iv., 76
in Peruvian mummies, iv., 77
used by Moqui Indians, iv., 77
Council report of the, ix., 1, 26, 55, 74, 98, 127, 137, 157, 204
Counting out rhymes, etc., vii., 39–43
Corona, solar, v., 245–247, 254
photographs of, 246
observations of, viii., 153–156
Coronado Beach, x., 31
Corrosion of iron wire cables, iii., 65, 66
Corundum, iii., 21, 53
ancient use in drilling rocks, iii., 105; vi., 6–11; vii., 250
American, viii., 160
Corundum from Mexico, ii., 117
Cove Field's fauna, vii., 3
Corrania Mexicana, viii., 80
Cox, Charles F., elected Treasurer, xii., 128
Crampton H. E., elected resident member, xiii., 234
Cranial nerves of Amphibia, xii., 56
Cranial nerves of Amphibia, origin and distribution, xiii., 176
Crania, viii., 4, 5, 6, 116
delineation of, viii., 135–136
Crassaletta Delawarensis, ii., 12–13
Craters, lunar, xii., 93
Crawfish in caves, i., 59, 65–67
Creasoting treatment of wood, v., 116, 118
Creation, account of, ii., 106–110
vii., 141–151, 159–162
Credneria, v., 134
Crenic acid in peat, i., 76
Crepidula, peculiar growth, xv., 40
Cretaceous Leaves from Long Island, xiii., 180
Cretaceous age of Dakota sandstones, v., 133
flora of North America, v., 133–137
plants from Staten Island, v., 28, 29
rocks, Staten Island, v., 229
strata in Colorado, v., 126
strata in Nebraska, etc., v., 133-135
system, comparative table, v., 135
rock, vii., 39
of Syria, vii., 168, 174, 175. 176
of Long Island, viii., 177–181
of New Jersey, viii., 47, 178, 179
of Staten Island, viii., 31, 177–181
flora of North America, viii., 176
formation on Staten Island, palæontology of, xi., 96
formation on Long Island, xii., 222
palæobotany of Staten Island, xii., 28

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mammals, xii., 27
of Staten Island, vi., 16
crust of earth, vi., 28–33
flexibility of, vi., 32, 33
thickness of, vi., 28–30, 37
period, temperate climate, iii., 94, 95
teliosts, activity of, iii., 54
strata, i., 15–24
in Chihuahua and Texas, ii., 90, 94, 95
marl-belt of New Jersey, ii., 9, 13, 85, 138, 139
Crichtonite (?), vii., 219
Crinoidea, ix., 139
Cripple Creek gold mines, xv., 127
Crocidolite, viii., 17; x., 4
of South Africa, iii., 104
Croton capitatus, vii., 13; ix., 182
argyranthemus, ix., 181
glandulosis septentrionalis, ix., 181
gracilis, ix., 182
Neomexicanus, ix., 185
Croton water supply, viii., 517–112
Crow, A. Eugene, elected resident member, xii., 137
Crowsfeet or Caltrops, iv., 40
Cruciferæ, vii., 7
Crustacea, v., 41–42
viii., 152
Crumplings of clays, xiv., 20
Crustacea, palæozoic, viii., 152
Crusiana, iv., 78
Cryptidine, ii., 63
Crystalline rocks bordering Trias of New Jersey and Pennsylvania, v., 19, 20
Crystals of calcite, iii., 19, 20
diamond, iii., 21–72, 105–107
quartz resembling diamonds, iii., 72
ruby, iii., 21
of metallic tin, xi., 96
spheres, v., 233–267
of Zircon, vii., 6
ice, x., 120
Ctenodus, ii., 145–146
Cuba, W. I., cultivation of sugar-cane, iii., 15, 16
of sorghum, iii., 5, 6
of sugar-beet, iii., 5, 6
of sugar-cane in Cuba, iii., 15, 16
Cucullæa, ii., 11
Cucurbitaceæ, iii., 45; vii., 9
Cucurbita fœtidissima, ix., 184
Cumarine, v., 197
Cupric hydrate, v., 215
Cuprified wood of Texas, i., 17–21
Cuprite, viii., 13; x., 143
Curacaco flora and funna, ii., 151
terrestrial molluscs, ii., 151, 152
meteorological notes in, iv., 47
Curmatinæ, revision of, viii., 177
Curtis, H. S., elected resident member, xiii., 171
Curtis, John G., elected resident member, xii., 25
elected sectional chairman, 66
man, 66
Curves of efficiency, i., 113, 114
Cuscuta indecora, vii., 12
arvensis, ix., 185
Cushing, Prof. H. P., elected corresponding member, 63
Cutter, Rev. Manasseh, paper on sea anemones, vii., 244
Cutting of rock crystal, etc., v., 266, 267
of the diamond, ix., 146
Cyanite, viii., 22–162
Cycads in cretaceous, v., 134–136
Cycas, iv., 47
Cyclones in the West, iii., 3–5
Cyclops, ix., 33
Cyclostomata, vii., 259
Cyclura bocolopha, x., 52
Cygni, notes on, x., 61; xiii., 170
Cylindrella, ii., 152–153
Raveni, ii., 152
Cymbella, xii., 220; xiii., 101
Cyperaceæ, vii., 14
Cyperus Mristatus, vii., 14
Berkleyi (new) ix., 13
cyrtolepis, ix., 182
lævigatus, (new) ix., 14
uniflorus, ix., 182
Cypris, ix., 33
Cyprina Morrisii, ii., 12
Cypsilidæ, iv., 34
Cyrtoceras, viii., 115
Cyrtolite, viii., 185
Cystids, vii., 2

Dactylethra, vii., 257
Dædalea confragrosa, v., 111
vorax, v., 111
Dakota, minerals from, iii., 17
Sandstones, v., 133–134
tin mines of, viii., 146, 148, 150

Digitized by Google

Dalbergia Rinkiana, xii., 236
Dalea formosa, ix., 183
lasiatha, ix., 183
laxiflora, ix., 183
nana, vii., 9; ix., 183
lasianthera, vii., 9
Dalmanites anchiops, i., 57
Dam, Quaker Bridge, viii., 117–125
Dammara, v., 136
Dammara borealis, xii., 31
Damourite, ii., 25; viii., 12
Dana, James Dwight, memorial of, xiv., 260
Danburite, viii., 162
Daucus pusillus, vii., 10
Daphnetine, v., 197
Darkening of atmosphere by smoke, iii., 60–61
Dasylirion, iii., 39
Dasylirion Texanum, ii., 93
Dasyurus, xii., 51
Dates of erection of pyramids, ii., 115, 116
Datolite from Weehawken, N. J., i., 129; ii., 88; vii., 231; ix., 142, 143
Davis, E. H., death of, vii., 237
Davyum, v., 200
Dean, Bashford, elected Curator, xii., 128
Death of Prof. A. W. Von Hoffman, xi., 155
of Dr. T. Sterry Hunt, xi., 72
of Dr. John C. Jay, xi., 32
of Dr. John I. Northrup, xi., 1
of Dr. L. M. Rutherfurd, xi., 155
Decay of building materials, v., 56–71
of wood, v., 72, 110–120
of building stone, ii., 67–79, 120–138
of wood, viii., 85, 86, 89, 110
De Candolle, Alphonse, death of, xii., 187
Deceased members, iii., 2, 33, 37, 56, 66, 80
Decease of members, ix., 4
Decipium, v., 200
Decomposition of meteorites, v., 231
of pyrites, v., 231
of rocks, v., 118
of wood, v., 110–120
Deep-well temperatures, xiii., 6
Deer in Syria, vii., 171
Deformation of skulls, viii., 4, 5, 6, 116
Delaware Valley, gravels, iii., 7–12
Delphinum azureum, ix., 183
Delphinus delphis, xii., 50
DeMelli, Mr. H. A., viii., 156
Dendrodus, vi., 138
Dentrophycus Triassicus, vi., 126
Dentalium elephantinum, iii., 62
Dennett, W. S., M. D., elected member, xv., 134
Dentition of elephants, i., 153
Denudation of the two Americas, v., 77–78
Deposits, surface, x., 8
Dermal appendages, vii., 80
Descloizite, iii., 100
Description, new species Aplodentia, v., 179
new species bird, etc., v., 17
placoderm fishes, etc., v., 25–28
of new tribolites, vii., 247
of new Titanichthys, vi., 164
Desert of Sinai, ix., 104
flora and fauna of the, ix., 125
geological notes on, ix., 122
minerals of the, ix., 124, 126
physical geography of, ix., 110
sand of the, ix., 123
sandstones in the, ix., 115
water of the, ix., 120
Desmanthus Jamesii, vii., 9
Desmodium, xii., 60
Desmodium canescens, ix., 183
Illinœnse, ix., 183
Tweedyi (*new*), ix., 183
Destruction of Adirondack forests, iii., 35–37
Destructive influence of fungi, v., 110–120
Determination of organic matter in water, ii., 111–114
Development of aëronautics, vii., 113
science in New York, xii., 242
Devil's corkscrew, xiv., 66, 79
Devonian fishes, vii., 178–179
fishes in Edinburgh museum, viii., 11
formation, ii., 1
placoderms armor, iii., 54
of Ohio, fishes on, v., 25–28
of New Jersey, vi., 59
Devalquea Haldemiana insignis, xii., 86

Digitized by Google

Deweylite, iii., 17
Diabantite, viii., 17
Diabase, i., 21; xiv., 201, 213
dikes in Thousand Islands, xiii., 213
Diagonal trends of the earth's crust, ix., 15
Diamond cutting and polishing, ix., 146
washing, ix., 147
from Butte county, Colo., iv., 35
from North Carolina, vi., 39
from Georgia, vii., 166, 251
great orange, vii., 49
Koh-i-nor, vii., 49
origin of, vii., 236
North American, viii., 159, 160
x., 49
from Wisconsin, xiii., 145
crystals of, iii., 21, 72, 105, 107
illustration of hardness of, iv., 59
Dianthera parvifolia, ix., 181
Diatomaceæ, vi., 50
Diatomaceous earth, xii., 217
Adirondacks, xiii., 97
New Jersey, viii., 16
Diatomeæ, ix., 33
Diatome structure, xiv., 71
Diatoms, x., 119
in Beaver Pond, xiii., 188
in clays of New York State, xiii., 165
Dichoplectella, xiv., 112
Dickerson, E. N., elected resident member, xiv., 220
Dicksonia, v., 136
Dicorea Brandegei, viii., 77
Dictyonema flabelliforme, Eichwald, xiv., 272
Dictyopyge macrura, vi., 127
Dicynodont reptile, v., 20
Didelphys, xii., 187
Didymium, v., 185; vii., 220, 236
Diffraction of sound, viii., 130, 131
theory of corona, v., 246
Dikes in Essex county, New York, xiii., 229
Dimorphous foliage of Sphenophyllum, iii., 46
Di β (new element), v., 200
Dinichthys, ii., 147; iii., 20; v., 25–28; vi., 164, 165; xii., 187
corrugatus, v., 26
Curtus, vii., 179
Gouldii, v., 26
Hertzeri, v., 26
minor, v., 26
Terrelli, v., 26; vii., 179
tuberculatus, vii., 179
Dinichthys, vertebral column, fins and ventral armoring of, xv., 157
anterior ventrals, xv., 159
posterior ventrals, xv., 159
Notochordal area and vertebral arches, xv., 161
supporting elements of the dorsal and pelvic fin, xv., 162
Dinichthidæ, v., 28
Dinocerata, iv., 20
Dinosaurs in Brussells museum, viii., 11
Dinosaur skeleton in Connecticut, v., 17
Dinotherium, iv., 20, 22
Dinwiddie, Mr. Robert, death of, viii., 2
Diodontidæ in American seas, v., 89
Dionæa, xii., 9
Dioömites longifolius, vi., 126
Diopside, viii., 162
from DeKalb, New York, i., 136
Dioptric and diffractive images, ii., 83
Diorite from Colorado, vii., 16
in Syria, vii., 168, 174
porphyrite, xiv., 210
orbicular, ix., 145
Dioryte, i., 21, 49; ii., 94–95, 149
Diospyros, v., 136
Diospyros primæva, xiii., 181
Steenstrupi, xii., 34
Diplachne dubia, ix., 182
Dipleurus, v., 18
Diplognathus, ii., 147
Diplognathus mirabilis, v., 27, 28
Diplograptus foliaceus, vii., 3
Ingosus, vii., 3
Diplotheca Hyattiana xiv., 130
Diplurus, fin structures of, xiii., 22
longicaudatus, vi., 127
Diphenylamine-acrolein, i., 127–128
Diptera, v., 45
Dipterus, ii., 146; vi., 127
Dipterusvalenciennesi, xiii., 131
Discogloseus xii., 245
Discharges, vacuum, xi., 72, 124
Discoveries by Priestley, vii., 198

Digitized by Google

Discovery in prehistoric mounds of Ohio, iii., 97
of chloroform, xi., 149
of elements, v., 181
of the New World, influence of Science upon, xii., 242
of North Pole, i., 40–48
of stone implements at Trenton, iii., 1, 7, 12
of substances, iii., 192, 193, 197, 199
of tablets in Valley of Euphrates, ii., 110
Discussions, ix., 4, 5, 21, 37, 38, 45, 46, 69, 70, 83, 94, 95, 103, 136, 199, 200
Disease germs, vi., 57
Disintegrated sandstone at New Durham, ii., 117–120
Disporum trachycarpum, viii., 79
Distilling apparatus, xii., 54
Distinction between ontogenic and phylogenic variation, xv., 141
changes by environment, xv., 142
Distribution of time, mode of, i., 86–87
Divination, vii., 42
Division of Eutherian Mammals, xiii., 175, 234
Dodge, R. E., elected member, xv., 34
Doe River Gorge, East Tennessee, v., 220
Dogfish, Anatomy of the Ear of, xv., 176
Sacculus, 177
Lagena, 178
Utriculus, 178
Sinus Utriculus, 178
Recessus Utriculus, 179
Semicircular Canals, 179
Ampullæ, 180
Nerve supply, 180
explanation of figures, 181
Dog-tooth spar, vi., 221
Dolomite, v., 216
in San Juan mts., v., 122, 125
in Staten Island, v., 229
pink, vi., 39, 91
viii., 21, 51, 53, 54
Dolomyte, durability, ii., 128–130
of New York Island, iii., 48–49
vii., 21, 68, 215, 217, 218, 219, 221, 224, 227
Domestic animals, terms used, etc., vii., 120–122
Dominion Government Survey Reports, xiv., 191
Donald, James M., elected member, xv., 147
Doricha evelynæ, x., 52
Dorchester sandstone, ii., 124, 125, 136
Ohio sandstone, ii., 125, 126, 136
of dolomyte, vii., 24, 34, 38
of pyrite, vii., 38
of stone, vii., 175
of marble, iii., 100
Double Stars, v., 259
Douglass, James, elected member, xv., 147
Draba platycarpa, vii., 7
Dracocephalum, xiii., 98
Draper, J. W., memorial of, i., 77, 105, 108, 163
Draper, Dr. H. W., memorial of, ii., 36
Drift, glacial, vii., 18, 39, 50–54, 59
glacial, vi., 12, 18
pre-glacial, vi., 16, 18
Drift-hills of Western N. Y., i., 77–80
Drilling of rocks by the ancients, iii., 105
Driven wells, vi., 77–91
patents for, vi., 91
"Dry rot" in timber, v., 110–120
Dues and Fees, vii., 129–130
viii., 126
Dufreynite, ii., 13
Dumortierite, vii., 230; viii., 161
Dunegan meteorite, vii., 6
Dunes of Syria, vii., 167
Durability of blue sandstone, ii., 126, 136
brown sandstone, ii., 122–124, 136
building stone, ii., 73–75
gneiss, ii., 135, 136
granite, ii., 134, 135, 136, 138
limestone, ii., 128, 136, 137
marble, ii., 128, 133, 136
Dust columns at Sombrero Island, iii., 3
Dutch Gap, x., 36
Duties on specimens, ii., 79
Dwellings, cliff, x., 44
Dyckman, Mr. Isaac M., elected resident member, xiv., 68
Dyer, H. G., elected resident member, xiii., 23

Digitized by Google

Dies, natural, xi., 48
Dryopithecus, viii., 135
Dykes, xiv., 210
"Dynagraph car," v., 151
and track inspection car, iv., 5
Dynamic electricity, review of, v., 89–110
Dysodia Chrysanthemoides, viii., 78
Cooperi, viii., 78

Eads, Capt. James B., viii., 166–174
military services of, viii., 171, 172
proposed ship railroad, viii., 174
removal of Miss. bar, viii., 171
Earle, H. Deforest, elected resident member, xiv., 220
Earlier civilizations, woman's part in, xi., 29
Earth, astronomy of, v., 234
axis of, v., 235
form and size of, v., 234
rotation of, v., 236
Earth's axis, change in position of, iii., 89, 90, 95; xii., 147
crust, temperature of, xii., 186
Earthquakes, vi., 18–35, 36–39, 65
bibliography of, vi., 34, 35
cause of, vi., 33, 38
explosion, vi., 27
famous, vi., 36, 37
focus of action, vi., 26
frequency of, vi., 24, 34, 36, 37
in Japan, etc., vi., 92
record of, vi., 24, 25
in Palestine, vii., 171
in Yucatan, vii., 47
waves, viii., 83
waves on Pacific coast, v., 79
Earth-wax, deposits of, ii., 43–50
Earthworm, lime gland of, xv., 126
Eastern Yucatan, etc., vii., 45–48
Echinarachnius parma, ii., 26
Echini, v., 37, 39
Echinocactus setispinus, vii., 10
Echinoderms, fertilization of, xiv., 45
Echinorhynchus, ii., 8
Echinospermum Redonskii, vii., 12
Eclipses, solar, v., 245, 246
Eclipse, solar, of 1889, x., 153–156
of the Sun, ix., 5, 47, 52
expedition to South Africa, x., 2
solar of Oct. 20, 1892, x., 26
Economical expansion in steam engines, absolute limit, ii., 1
Edestus, vii., 100
Effects of vegetation on the surface, x., 14
Effusive and Dyke rocks near St. John, N. B., xiv., 187
of St. John, Literature of, xiv., 188
rocks of St. John, xiv., 195
Eggs of plover, xi., 24
Egypt, pyramids of, ii., 114–116
obelisks of, ii., 138
topography of, iii., 78, 79
geology of, ix., 122
Egyptians, ancient, the language of, iv., 60
catacombs, v., 120
origin of alphabet, v., 81–88
Eigg, Hebrides, singing beach at, ii., 73
Eka-silicon (predicted element), v., 183
Elæolite syenite, xi., 60
Election, annual, i., 126–127
ii., 98
of fellows, iii., 80
of members, iii., 1, 18, 31, 32, 37, 48, 55, 71, 72, 80, 100, 106.
of officers, iii., 70–71
of members, v., 9, 25, 80, 110, 137, 169, 213, 232
of officers, v., 165
vi., 110
of fellows, vii., 44, 71
of officers, vii., 134
of fellows, viii., 174, 175
of members, viii., 29, 85, 174, 188
of officers, viii., 129
annual, ix., 108
of members, ix., 1, 27, 36, 55, 71, 74, 84, 98, 127, 128, 157, 204
of officers, ix., 109
of officers 1896–97, xv., 133
Electric arc, radiation of, v., 240
winding apparatus, etc., v., 153–157
Electric currents from batteries, x., 105
by induction, x., 105
by meters, x., 118
stations, flywheel accidents, xiv., 65
Electric railway, vii., 68, 70
Electrical discharges, their bearing on solar physics, xii., 48, 49
resonance, xiii., 122

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Electrical resistance, range and accuracy in measurement of, xiv., 65
Electricity, dynamic, v., 89–110
upon comets, v., 255
applications of, x., 116
Electrolysis, v., 186, 187
literature of, i., 163
Elementary substances, v., 181, 183, 200, 244
discovery of, v., 181, 183
Elephant, African, i., 153
Elephas, iv., 20, 22, 25
Elephas Americanus, vi., 59
Antiquus, viii., 135
Indicus, anatomy of kidney of, xiii , 110
Elephants, ancient and modern, iv., 19
small, from Farther India, iv., 19
Elephant's tooth, iv., 59
Elevation of Champlain deposits, iii., 95
"Elgin sandstones," v., 20
Elizabethtown, N. Y., Pleistocene Lake bed at, xiii., 107
Ellenville, N. Y., quartz crystals from, xiii., 181
Elliot, Mr. S. Lowell, death of, viii., 128
Ellipsocephalus galeatus grandis, xiv., 139, 140
Elves of the air, xi., 123
Emargination of wing feathers, vii., 19–21, 75–78, 80–87, 89–100
Embryonic Baculites from the Black Hills, xiv., 63
Embryology of Amblystoma, vii., 255
newer problems of, xiv., 76
Emerald from North Carolina, ii., 3
Emeralds in North Carolina, i., 101–105
in North Carolina, viii., 2, 160
of North Carolina, iii., 95
vii., 212, 224, 250
Encelia calva, vii., 11
subaristata, vii., 11
Enclosure of spinel in ruby, iii., 21
Energy of sun, v., 240
Engelmannia pinnatifida, vii., 11
Engineer's club of Philadelphia, vii., 72
Engis skull, viii., 135
Eñagonum, i., 8
Enstatite, viii., 49
Eocene limestone near Green river, iii., 13
of Syria, vii., 168
Eozoon, ii., 1
Ephedra, iii., 47
antisyphilitica, ix., 182
Epidendrum tampense (new), ix., 13
venosum, ix., 13
Epilobium paniculatum, viii., 80
Epidote, ii., 25, 150
at Cranberry mine, v., 221
with chalcopyrite, v., 121
vii., 6, 49, 57, 63, 213, 219, 223, 226
viii., 45, 50, 53, 54
Epidosyte, vii., 57
Epithemia, xiii., 101
Epsomite, viii., 22
Equisetum laticostatum, v., 17
Equisetum Rogersi, vi., 126
Eragrostis Minor, ix., 182
oxylepis, ix., 182, 185
Erasure of names, vii., 193
Erax multicaulis, vii., 11
Erbium, vii., 220
Erection of building-stone on edge, ii., 122
Eremacausis, v., 118
Eremophila Alpestris, ix., 129
Erigeron tenuis, vii., 10
flagellaris, viii., 79
glabellus, viii., 78
Eriochloa sericea, ix., 182
Eriogonum, viii., 77, 81
Abertianum, viii., 77
annuum, viii., 77
cernuum, viii., 77, 80
deflexum, viii., 81
flavum, viii., 81
Mearnsii, viii., 72
microthecum, viii., 81
racemosum, viii., 77
trichopodum, viii., 77
vimincum, viii., 77
Wrightii, viii., 77
Eritrichium Jamesii, viii., 80
glomeratum, viii., 80
setosissimum, viii., 80
Eroding power of ice, viii., 164
Erodium Texanum, vii., 8
Evolvulus sericeus, vii., 12
Erosion in Catskill mts., i., 24–31
in valley near Charmouth, Eng., i., 27–28
of limestone, i., 60, 65

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Erosion of caves, ii., 3–6, 39–40
of glacial, in North America, iii., 51–52
of continents, v., 78
of the Alleghanies, viii., 149
x., 8
Errata, x., 121
Error of clocks, v., 153–154, 158–162
Erubescite, vii., 217
Eruption of Krakatoa, viii., 82, 83
Eruptive Rocks, v., 121–130, 222,230
from Colorado, vii., 16
xv., 121
Ervilia, ix., 34
Erythræa Beyrichii, ix., 185
Erythrite, viii., 59
Eschara digitata, ii., 12
Eskimo period, iii., 10
Esquimaux use of iron, v., 227
Essex township, Geology of, xiii., 214
Essonite, v., 75
from Delaware, vii., 225
vii., 212, 225
Estheria ovalis, v., 17
Eta Cassiopeiæ, Parallax of, xiv., 87
Etcheminian series, older than St. John's group in New Brunswick and Newfoundland, xiv., 105
subgroup, xiv., 194
Ether, luminiferous, v., 77
solidification of, v., 191
Ethnological research, ix., 2
Ethnology, section of, x., 109
Ethylene, v., 191
Ettringite, xii., 70
Eubalæna Sieboldii, i., 147
Eucalyptus, vii., 67; xii., 236
Geinitzi, xii., 31, 34
xiii., 133
Euglena, ix., 34
Eunotia, xii., 220; xiii., 101
Eupatorium Greggii, vii., 10
incarnatum, vii., 10
Euphorbia, xii., 38
melanodenia, vii., 13
Peplidion, vii., 13
campestris, viii., 79
Pringlei, viii., 79
albomarginata, ix., 181
angusta, ix., 185
fuxifolia, ix., 185
Fendleri, ix., 185
Preslii, ix., 185
Serpeno, ix., 185
Wrightii, ix., 185
Euphorbiaceæ, vii., 13
Euplotis, ix., 34
Eurite, viii., 49
Eurypterid, new, from Catskill group, ii., 8
Eurypterus, xii., 241
Eutermes, viii., 87–97, 104–114
nests of, viii., 88–95
ravages of, viii., 90–93, 99, 100
"soldiers," viii., 90, 95, 104–111
ix., 159
Eutherian mammals, division of xiii., 175, 234
Euxenite, viii., 159
Evax multicaulis, ix., 181, 182
Evening Post, vii., 254
Events of the year, vii., 130
Evidences of subsidence and elevation, x., 18
Evolution, vii., 158, 162
conception of species as modified by xiii., 132
Discussion of causes, xiii., 156
of head, vi., 135
of horns, xiv., 62
requiring neither natural selection or acquired characters, xv., 148
in shells, viii., 114, 115
of solar system, v., 249
of the horse, xi., 107
of the teeth, xii., 187
of vertebrate, ii., 64
Excavating power of glaciers, i., 2–30
in ancient mounds, ix., 199
Exchange list, vii., 131, 133; xii
Exchanges, vi., 167–182
Excretory system and origin of pigment in Nephelis and Clepsine, xiv., 67
Exhaustion of soil in America and Cuba, iii., 16–17
Exhibition of Spanish chestnuts, xi., 13
Exogyra, xii., 225, 226
Exogyra costata, ii., 10
Expeditions to Florida and Georgia, vi., 60–65
Experiments on durability of sandstones, ii., 127
in electricity, v. 89–110
on the isotropy of the egg, xiii., 206
Exploration of America, xi., 60–65

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Exploration of Arctic, i., 46–48
in Greece, viii., 188
Explosion of Flood Rock, v., 14
Explosives, v., 194
Extinction of the Mammoth, iv., 19, 23, 25.
Eysenhardtia amorphoides, vii., 9

Fairchild, Prof., resignation as Secretary, viii., 1, 4, 7
Fairweather meteorite, ix., 97
Fulgora lanternaria, vii., 67
Falls of Niagara, Preservation of, iv., 54
Famous bridges, vi., 155–160
Farrand, Dr. Livingston, elected resident member, xiv., 92
Farrand, Dr. Livingston, elected Secretary of subsection of Anthropology and Psychology, xv., 154
Fat in human milk, ii., 140
Faults in southwest Virginia, i., 159
at Cove Creek, Utah, 171
Faunas of Atlantic Coast, xiv., 103
in New Brunswick, xiv., 104
(Sub.) of Band b of St. John group, xiv., 101
of the Cambrian, xiv., 109
Fauna of Syria and Palestine, vii., 177, 178
of the desert of Sinai, ix., 125
Faunas of the Upper Ordovician strata at Trenton Falls, Oneida Co., N. Y., xv., 71
History of the term "Trenton Limestone," 71
Original descriptions of the type section, 72
Stratigraphy of the Trenton Falls section with faunal lists, 74
of the Poland Bridge section with faunal lists, 81
of the Poland Lime-kiln section with faunal lists, 82
of the Rathbone Brook section with faunal lists, 84
Conclusions, 87
Summary, 88
Physical features of the Trenton Falls section, 89
List of fossils for which Trenton Falls is the type locality, 91
Table of faunas of the various zones, 93; (Plates ii., iv.)
Faunas of the Paradoxides Beds, xv., 192
Favosites, iv., 29
Fees and dues, vii., 129, 130; viii., 126
Feldspar in N. Y. Island, v., 77
in San Juan Mts., v., 121, 128
in Staten Island, vi., 12; vii., 55, 56, 58, 61, 62, 217, 221, 227; viii., 162
Felipe Poey, obituary notice of, x., 56
Fellows, election of, iii., 80; vii., 44, 71, 129; viii., 174, 175
Felsite Porphyry of St. John, xiv., 197
Felsyte, i., 21
Fendlera supicola, viii., 80
Fenesletta. i., 57
Fenistella, iv., 29
Fenocyclea, iii., 21
Ferns and their allies, ix., 26
in Cretaceous, v., 134–136
Ferguson meteorite, ix., 198
Fergusonite, viii., 159–185
Ferric oxide, vii., 37
Ferrous oxide, vii., 37
Ferruginous quartz, vii., 223
Fertilization and early development of the Ovum, xiv., 185
Festuca scabrella, i., 4
ovina, viii., 78
Fetid feldspar, vii., 229
quartz, vii., 58–62
Fibrolite, vii., 62, 230
Indian Scraper of, v., 72
Fibrous hornblende, vii., 224
Ficus, v., 136
Ficus Woolsoni, xii., 33
'Fields of Rocks,' vii., 16–18
Field work in local mineralogy, iii., 48
Fifth Mass of meteoric iron, v., 221
Filtration, vi., 43–48, 54–58
Fingal's Cave, ii., 37
Fin structures of Diplurus, xiii., 22
Fins, origin of, xii., 121
Fireopal, viii., 17, 159, 161
Fish, blind, in caves, i., 59–64
Fishes, Devonian, from Ohio and New York, ii., 144–147
from St. Lawrence, ii., 1
ancient, Armor of, iii., 54

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Fishes, fossil, of Chemung group, iii., 32
near Green River, iii., 13
from Wyoming, iii., 34-38
of N. America, v., 233
(see Fossil)
of Cayuga Lake, vii., 166
of Devonian of Ohio, vii., 178-179
placoderm, vii., 238
of L. Carboniferous, vi., 137, 138
of Trias, vi., 125, 127, 128
of the Pacific Coast of America, xi., 125
Fissurella, x., 7
Fistulina hepatica, v., 111-114
Flames, sensitive, viii., 131, 132
Flexibility of marble, ii., 130-133
Flexure of strata in Catskills, i., 24-25
Flight of birds, vii., 19-22, 75-78, 80-87, 89-100
Flint chips in Palestine, vii., 170
nodules in Syria, vii., 174
implements of Syria, vii., 167-168
implements at Amiens, iii., 80
Flood Rock explosion, v., 14
Flora of Arizona, xiv., 21
of Bolivia, x., 115
cretaceous of N. America, v., 133-137
of "Amboy" clays, v., 136
of tertiary age, v., 137
of Syria and Palestine, vii., 177, 178
cretaceous, viii., 176
of Arizona, viii., 61-81
of Mogollen Mts., viii., 60-76
of the desert of Sinai, ix., 125
of Laramie, x., 5
Florida, unknown vertebrate on shore of, v., 165-168
reef, vii., 254
shell-mounds of, viii., 164, 165
phosphate beds of, ix., 85
Florissant, Col. fossil insects, iii., 13
fossil palm, iii., 77
Flosferri, vii., 221
Flint-bearing quartz crystals, i., 131-136
cavities in topas, ii., 42
cavities in minerals, iii., 13, 81, 107
Fluids, solidification of, v., 191
Fluocerite, vii., 220
Fluorite, ii., 25; vii., 220; viii., 50, 59, 60, 185
phosphoresence of, iii., 77-100
Fluoplumbates, xiv., 1
Fluoplumbic acid and lead tetrafluoride, xiv., 4
Fluorescent amber, viii., 158-162
Foliage of Sphenophyllum, dimorphous, iii., 46
Folk-lore, vii., 39-43
new study in, vii., 120-122
society, vii., 78
ix., 134
Society, American, x., 37
Fontainebleau sandstone, viii., 42, 44
Foods, ii., 95
Food and fibre plants of North American Indians, iv., 35
Footprints, Triassic, vi., 125
Foraminifera, ix., 33
Foraminifera of Protolenus Fauna, xiv., 109
Forces, unity of, i., 98-99
Ford, James B., elected resident member, xiv., 220
Forest and Stream, vii., 86
Forest City meteorite, ix., 200
culture, ix., 57
Forests, destruction and preservation, iii., 35-37
smoke produced by fires of, iii., 60-61
Forest growths, succession of, iii., 36
petrified in Colorado, iii., 6-7
Forestry in Europe, viii., 31, 32, 34
in New York State, viii., 31-40
conference on, ix., 56
legislation, ix., 62
report of the committee, x., 115
Forestiera Neo-Mexicana, viii., 76
Formalin in injecting media, use of, xv., 99
Formation of the Bahamas, x., 21
of the clays north of New Providence, x., 19
of Section of Biology, xi., 127
Formicaridæ, i., 176
Formicivora griseigula, n. sp., ii., 151
Formulæ, graphic, v., 195-197
Fort Washington Avenue and New Speedway; discoveries of rare minerals on, xv., 105
Fossil Corals, vii., 247
crustacea, vii., 247
fishes of Carboniferous, vii., 165
Erie shale, Ohio, vii., 178-179

Digitized by Google

Fossil plants, vii., 89, 113–115
shark, from Ohio, vii., 178, 194
fish at Frankfort, Ky., xiii., 109
fishes, Carboniferous, vi., 137
Devonian, vi., 59
Triassic, vi., 127, 128
Monograph on, ix., 2
sharks, ix., 131
Fossil fishes of N. America, v., 233
of Chemung and Catskill (title), v., 281
Fossil hunting in the Northwest, xii., 55
Fossil plants from Worcester, Mass., iv., 75
"Dakota" sandstones, v., 133–134
Fossil plants, Cretaceous, vi., 16
Devonian, vi., 59
Triassic, vi., 125, 126
Tertiary, xi., 123
resins, i., 85–87
fishes, ancient armor of, iii., 54
from Chemung of Penn., iii., 32
near Green River, iii., 13
from Wyoming, iii., 34, 38
insects at Florissant, iii., 13
palm at Florissant, iii., 77
near Green River, iii., 13
of Loess formation, iii., 14
plants from Providence, R. I., iv., 76
resin, surface of, viii., 157, 158
Devonian, vi., 59
Triassic, vi., 124–128
from phosphate beds, vii., 246
in drift, vii., 51, 52
in Palestine, vii., 171
in Syria, vii., 167–8, 171
of Quebec, vii., 2–5
new species from Ohio, i., 95
Foster, L. S. elected resident member, xii., 137
Foster, Scott, elected resident member, xv., 147
Foucault currents, xv., 97
Fourth Monobromphenole, iii., 32
Franklin Furnace, N. J., micaceous minerals from, xiii., 97
Allanite from, xiii., 102
Caswellite from, xiii., 181
ore bodies at, xiii., 22, 76
Franklinite, ii., 64
ores analyses of, ii., 26–35
Frasera speciosa, viii., 78
Fraxinus pistaceifolia, viii., 76
Free gold, x., 59
Freezing by cold evaporation, iv., 80
Freia, ix., 34
Freight rates of railways, v., 150
Frenatæ, xiv., 51
French Creek Mines, Penn. Minerals from, iv., 41
Penn. Minerals of, viii., 56–59
Frenelites Reichii, xii., 29
Freshwater pearls, viii., 163
Fresnel bi-prism, xv., 135
Fresnel's Formulae for Vitreous Reflections, Application of, xiv., 172
Frigate bird, soaring of, vii., 83, 86
Frissell, A. S., elected member, 147
Front Range, Colorado, vii., 243
glaciation of, viii., 164
Frost effects and sulphate of soda efflorescence shown in Building Stones, xiv., 67
Fuel of locomotives, v., 144–146; 150
Funds of the Academy, viii., 126
Fungi, v., 110
acid secretion of, v., 71–72; 114, 118
inducing decay, etc., v., 110–120
Funnels and Vesiculæ terminals in Nephelis, etc., xiii., 206
Furfurran, v., 195
Fusion-structures in meteorites, i., 153–155

Gabbro, viii., 54, 55
from Pennsylvania, xii., 71
at St. John, N. B., xiii., 197
Gadolinite, viii., 159, 162, 185
Gailenreuth, bone-cane, ii., 37
Gaillardia pulchella, vii., 11
simplex, vii., 11
suavis, vii., 11; ix., 102
Galactia heterophylla, vii., 9
marginalis, vii., 9
Galena, ii., 94–95, 149
changed to sulphate, v., 130
in Indian mounds, v., 73–74
in San Juan mts., v., 123, 126, 128
from New York City, vi., 41, 130
viii., 60, 140
argentiferous, x., 62
Galen's Treatise upon Practical Anatomy and Experimental Physiology, xiv., 66

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Galenite, iii., 2, 23
Galicitis, xii., 51
Galium virgatum, vii., 10
Wrightii, viii., 80
microphyllum, viii., 80
Gallium, v., 183
Galvanometer method of measuring alternating currents with, xv., 35
Game-laws, viii., 36
Gammarus, ix., 33
Garbett, Mr. Samuel, viii., 24
Garden, sea, x., 5
Garnet from New York Island, ii., 9, 18
Aplome, iv., 42; v., 75, 263-265
Almandine, v., 80, 265-266
Asteriation in, v., 225-226
from Colorado, v., 265-266
green, from New York, v., 121
large, from New York, v., 80, 265-266
in North Carolina, v., 222, 266
Garnet, viii., 59, 153, 161
Garnets, origin of, ix., 32
Garnets, x., 50
Garnetiferous schist, viii., 48, 49
Garrya Fremontii, viii., 76
Gas-analysis, improved method, ii., 101-102
Gas Film condensed in the surface of solid bodies with relation to
(1) Newton's rings of first order,
(2) Sand flotation,
(3) Sand in harmonic vibration, xv., 97
Gases, liquefaction of, v., 190-191
Gasteropoda of Protolenus Fauna, xiv., 151
Gasteropods, from streets of Hartford, iii., 20
Gaura coccinea, ix., 184
Drummondii, vii., 9
Sinuata, vii., 9
tripetala, vii., 9
Gauss and Weber, memorial to, xii., 93
Gay Head, Mass., deposits at, iv., 78
Geikie on decay of marble, ii., 132-133
Gems from Ceylon, iii., 17, 107
the mining and cutting of, iv., 58
of the U. S., viii., 160-162
Artificial, ix., 155
Tiffany, collection of, ix., 151
Genealogy of mammalia, v., 89
Genesis of crystalline iron ores, ii., 6, 8, 13-17
Genetic Relations of certain minerals of Northern N. Y., xv., 260
Genth, F. A. death of, xii., 93
Geodes of chalcedony, ii., 9
Geodetic Survey, U. S., iv., 1
Geological age, etc., of the Potomac, Group, x., 36
Geological age of North Atlantic Ocean, v., 77-79
Congress at Berlin, v., 20-25
Notes in Virginia, etc., v., 215-223
Geological climate, alternations of, iii., 94-96
in high latitudes, iii., 84-97
Geological Magazine, vi., 164
Maps, viii., 47, 129, 130
Survey of Illinois, ix., 132
Geological Section of East River Tunnel, xiv., 64, 273
Geological Section, xv., 3, 50, 70, 143, 153, 182
Geologic time, length of, vi., 41
Geologists in Philadelphia, xi., 45
Geology of the Adirondacks, xii., 19
Geology of the Bahamas, x., 4
Geology of country traversed by Northern Pacific Railroad, iii., 56
of Porcupine Mountains, iii., 14
of vicinity of Golden, Col., iii., 77
of Yellowstone Park, iii., 34
Geology of Essex and Willsboro Townships, Essex Co., N. Y., xiii., 214
North Shore of Long Island, xiii., 122
Ulster Co., N. Y., xiii., 165
of Gouverneur, N. Y., xii., 97
of Long Island, iv., 25
Northern Montana., iv., 2
of North Carolina, Mitchell's, xi., 45
of Skunnemunk Mountain, xi., 132
Wm. Maclure's, xi., 45
of Texas and Chihuahua, ii., 66, 94-95
Georgia, Minerals from, iii., 13
Geostilbia, ii., 152
Geraniaceæ, vii., 8
Geranium Carolinianum, vii., 8
cespitosum, viii., 79
Germany, state forests of, viii., 32

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Gesner's survey, xiv., 190
Geysers of Iceland, viii., 184
Theory of, xiii., 75
of Yellowstone Park, iii., 7
Giant's Causeway, ii., 3-5
Gibier, Dr. Paul, elected resident member, xi., 123
Gibsonville, N. C., supposed emerald, iii., 12-13
Giddings, F. H., elected resident member, xv., 147
elected permanent chairman of new section, xv., 154
Gifts to the library, viii., 4, 29
Gilia multiflora, viii., 80
rigidula, vii., 12
Gingko, iii., 47
Gizeh, borings in stone at, v., 120
Glacier Bay, Alaska, Areal Geology notes,, xv. 24
introduction, 24
general geology, 24
the Argillites, 25
the Glacier Bay limestone, 26
the quartz diorite, 27
diorites, 28
Crystalline schists, 28
dykes, 28
comparison with other Alaskan sections, 29
petrographical notes, 31
the quartz diorite, 31
the schists, 33
the dikes, 34
Glacier-ice, erosive power of, iii., 51-52
Glaciers, i., 167
excavating power of, i., 29-30
in western New York, i., 79
over Catskill's, i., 24-31
Glacial boulders in the Great Hudson Valley, iii., 24-26
epoch and subsequent warmth, iii., 92-93
epoch in North America, iii., 102
erosion in North America, iii., 51-52
gravels at Trenton, iii., 7-12
phenomena at Ontonagon, iii., 14
striæ on Shawangunk Mt., iii., 27-28
Glacial drift between New York City and Rockaway, iv., 35
and Preglacial drifts of New Jersey and Staten Island, iv., 26
Glacial observations in Canada and Northern New York, iv., 43
drift hills, v., 228
drift on Staten Island, vi., 12, 17, 18
drift in India, vi., 41
epoch, vi., 41
striæ, vi., 41
Glaciation in Catskill Mountains, i., 24-31
on New York Island, i., 30
on Staten Island, N. Y., i., 57
in Western New York, i., 78-79; ii., 2
in North America, ii., 155-159
of the Shawangunk Mt., iii., 22-30
Gland cells, mechanism of secretion in, xiv., 94
Glass discs, vi., 98-103
Glauconite, ii., 10, 12, 85
Gleichenia, v., 136
Glen Cove, N. Y., leaf bearing sandstones, iii., 30, 31
Gletscher-milch, produced by erosion, iii., 52
Glimpses of arctic scenery, ix., 156
Globigerina cambrica, grandis, didyma, turrita, xiv., 111
Glothlypis rostrata, x., 52
Glucose, v., 194
Glycerol, determination of xii., 55
Glycine umbellata, ix., 10
Glycosuvia, produced experimentally, xiii., 176
Glyptodon, iii., 53
Graphalium, xii., 37
Graphalium purpureum, v., 217
Gnathodon, ii., 141
Gnawed Beaver sticks, xiv., 6
Gneiss, v., 222-263
bordering Trias, v., 19, 20; ii., 70-72
varieties of, viii., 54
durability of, ii., 135, 136
Gneisses, petrography of, xii., 203
of S. E. Penna, viii., 50 member, xv., 134
Godkin, E. L., elected resident
Gold deposits in N. Y., i., 1
at Mt. Wheeler, Nevada, i., 7; ii., 50, 79-94, 95, 100-101
crystals of, v., 277
in pyrites, v., 192

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Gold in San Juan mts., v., 128
of Georgia, vi., 42, 60–65
ornaments from Florida, vi., 40–60; viii., 160
from Central America, vi., 40
native, viii., 7, 139, 140, 160
of North Carolina, viii., 139, 140
minerals, ix., 145
native, ix., 145
cure, notes on, xi., 151
free, x., 59
and iron, experiments upon, xiv., 182
Golden, Col., geology of, iii., 77
Golgi, method in nerve Histology, xiv., 71
staining, improvements in, xiii., 110
Lithium Bichromate in, xiii., 206
Gomphonema, xiii., 101
Gonobolus biflorus, ix., 185
Gonolobus parviflorus, vii., 12
viridiflorus, vii., 11
Gorden, Reginald, elected resident member, xv., 134
Gottlieb, Dr. J. Adelphi, elected resident member, xi., 40
Gould, Edwin, elected resident member, xiv., 277
Gould, Frank, elected resident member, xv., 147
Gould, Miss Helen, elected resident member, xv., 147
Gould's Comet, spectrum, ii., 20
Gouverneur, N. Y., geology of xii., 97
Government Commission for testing iron and steel, i., 149
Graduated Circles, periodic errors of, xiii., 205
Grahamite, viii., 26, 27
Grains and cereals, analyses of, x., 24
Gramineæ, iii., 45; vii., 14
Grand Canon of the Colorado, ix., 127
Grange Associations, scientific influence, iii., 16
Granite diorite from St. Johns, N. B., xiii., 188
of New York, xiv., 80
disintegration of, v., 62–69
on Staten Island, v., 228
varieties of, viii., 54, 55
pavements, viii., 42, 43
of Mounts, Adam and Eve, xii., 221
"Granules," on sun's surface, v., 241
Granulite, v., 221, 222; viii., 53–55
Granyte, disintegration of, i., 168; ii., 25, 70–72
durability of, 134, 135, 136–138
Graphic formulæ, v., 195
Graphite in meteorite, vi., 92; iii., 2, 50
vein at Bloomfield, ii., 147
Ticonderoga, ii., 148, 149
Graptolites at Navy Island, xiv., 264
from the Cambrian, new forms of, xiv., 165
Graptolithus pristiniformis, vii., 2
Gravel at Glen Cove, Long Island, iv., 33
Preglacial, iv., 26
at Trenton, implements found in, iii., 7–12
Gray copper, viii., 140
Great Appalachian Valley, v., 215–219
Bahama Bank, x., 4
Northern Railroad, ix., 57
Pyramid, ii., 114–116
quartz vein at Lantern Hill, Mystic, Conn., xv., 189
telescopes of the world, ii., 150
Greacen, Thomas E., elected resident member, xv., 147
Greece, explorations in, viii., 188
Green calcite, viii., 45
pearls, viii., 162
hornblende, xiv., 206
quartz, v., 229, 230
River, Col., Eocene limestone at, iii., 13
Greenland, discovery of, viii., 184
minerals from, iii., 104
Greenovite, vi., 130
Green sand, ii., 10, 12, 85
Greisen veins, viii., 137
Grewiopsis, xii., 33
Griffithides Sedaliensis, vii., 247, 248, 250
leminiferus, 249, 250
Gromia, ix., 36
Grotto of Capri, ii., 37
Grooved limestone pebbles, iv., 2
Growth of vinegar plant, vi., 66–70
Gryphæa, ii., 94

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Gryphæa Pitcheri, ii., 85
vesicularis, ii., 10-13, 85
Guano, ix., 85
Guatemala, obsidian implements, i., 105
Guilleminia illecebroides, ix., 181
Gulf Stream, viii., 117
Gulo, xii., 51
Gunnison Col. iron ores, i., 7
Gurhofite, v., 229
Guthrie, Ossian, elected corresponding member, xii., 93
Gutierrezia Enthamiæ, vii., 10
Sarothræ, vii., 10
Gutierrezia, viii., 77
Guyacum Coulteri, ii., 92
Guyot, Arnold, life of, iii., 66-68
Gymnosperma corymbossum, vii., 10
Gymnosperms, in cretaceous, v., 135-136
Gypsum in caves, ii., 38-40 ; iii., 19
and salt, Saltville, iv., 1
in Northern Texas, i., 17
Utah and Nevada, i., 172-173
Gyracanthus tuberculatus, iii., 104
Gyrating bodies, vi., 131-134
Gyroscope, vi., 131, 133
gyrostal and other rotating bodies, studies of, iv., 36

Habranthus, ii., 92
Habranthus Andersonii, vii., 14
Thurberi, viii., 78
Hæckel, Ernst, selected honorary member, xiii., 155
Hair hygrometer, use of, xv., 157
Hairless mouse of California, xiv., 45
Halectites, in Luray Cave, v., 217
Haliotis, viii., 162
Hallock, Wm., elected resident member, xii., 93
Hanksite, viii., 9
from San Bernardino county, Cal., iv., 79
Haplopappus spinulosus, vii., 10
Hardness of Brazilian diamond, v., 223-224
Harringtonite, v., 77
Harlem, minerals of, v., 74-77
Hartford, Conn., gasteropods in streets of, iii., 20
Hartley, Marcellus, elected resident member, xv., 147
Harpides, vii., 2, 3
Harvard College Observatory, photographs and Reclus planetary photographs, J. K. Rees, xv., 147
Havemeyer, Wm. F., elected resident member, xv., 147
Hawaiian Islands, x., 3
Head of a South American Indian, xi., 26
of sandstone from Staten Island, iii., 81
Health-foods, ii., 95
Heart of Africa, (title) vi., 165
Heat of earth, vi., 20-22, 29, 32, 33
of sun, action on stone, ii., 123
of sun, v., 240-241
from moon, v., 238
from chemical energy, v., 189
into electricity, v., 90-97
Heating surface required in steam-pipes, i., 67-70
Heavenly bodies, origin of, xiii., 170
Hedeoma Drummondii, vii., 13
Hedeoma procumbens, viii., 80
Hedera, v., 136
Hedysarum, xii., 58
Helenium amphibolum, vii., 11 ; ix., 182
elegans, ix., 184
Hoopesi, viii., 79
microcephalum, ix., 181
nudiflorum, ix., 182
setigerum, vii., 11
tenuifolium, ix., 184
Helianthus, i., 8
Helianthus annus, vii., 11
ciliaris, vii., 11
Maximiliani, viii., 81
Heliochrysum, v., 137
Helicoceras, ii., 94
Heliostat, xv., 135
with small mirrors, xv., 155
Heliozoa, ix., 33
Helix alternata, v., 218
pentodon, ii., 153
pomatia, xiii., 136
Hematite, ii., 7-8, 14-17 ; v., 217
of Gunnison, Col., i., 7
in Southwest Virginia, i., 162
Hemiptera, v., 45
Herderite, iii., 37
new locality, v., 80 ; viii., 12
Hering, Daniel W., elected resident member, xv., 147

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Herpestis chamædrorides, ix., 181
Herter, C. A., Elected resident member, xiii., 151
Heteropogon contortus, ix., 182
Heterotheca Lamarckii, vii., 10
subaxillaris, vii., 10
Heterotricha, ix., 34
Heuchera rubescens, viii., 79
Heulandite, viii., 50; ix., 143
Hexahydrobenzene, v., 195
Heys operation," v., 202
Heylyn, Mr. Edward, elected resident member, xi., 25
Hibiscus cerdiophyllus, vii., 8
Hicoria, ix., 185
Hiddenite, i., 2, 102; iii., 38; vi., 2, 3; viii., 161
Hieracium, note of a species of, vii., 17
Hieracium Fendleri, viii., 78
High Point, N. Y., lake at, iii., 29
High tides as geological agents, i., 80–85
High-water condition of the Mississippi, ix., 109
Hills, Sweet Grass, x., 57
Hipponicharion eos, xiv., 132
cavatum, xiv., 133
minus, xiv., 133
Hippopotamus tooth from Ramapo, N. J., xii., 24
Historic Bridges, vi., 148–160
History of Academy, v., 233–278; vi., 146, 147
History of chemical notation, ii., 53–57, 102–106
of Iceland, viii., 184
of Lexell's Comet, x., 119
Hoboken serpentine, i., 58
Hoboken, N. J., buildings of, ii., 67–71
Hodgkins' Fund prizes, xii., 219
Hoffman, A. W., von, death of, xi., 155
Hoffman, Rev. E. A., D. D., elected resident member, xiv., 220
Hoffmanseggia, viii., 78
stricta, ix., 184
Holocantha, ii., 92
Holley, Dr. A. L., memorial, of, i., 108, 147–149
Hollick, Arthur, elected curator, xii., 128
elected fellow, xii., 39
elected resident member, xi., 25
Hollow quartz crystals, vi., 122–124
Holmes' Comet, xii., 48
Holmium, v., 200
Holophagus, vi., 127
Holt, Henry, elected resident member, xiv., 220
Homalocenchrus encalypta, ix., 14
oryzoides (new), ix., 14
Virginica (new), ix., 14
Honey ants of New Mexico, iii., 103
Honeycomb, artificial formation of, iii., 107, 108
Honorary members, list of, iii., 123–125; viii., 217; x., (Supplement)
Horizontal moon enlargement, i., 116–118
Hornblende gneiss, v., 264
schist, v., 222
slate, i., 19–57
schist, viii., 49–52
Horned larks of North America, ix., 128
Horse, evolution of the, xi., 107
Horseshoe crab, larvæ, ii., 106, 107
Hosackia Mearnsii, viii., 65
Hospitals, infection of walls, v., 71
Hot Spring at Pagosa, Col., ii., 7
Hottonia inflata, iii., 43
Houghton, Mich., ancient mining excavations at, iii., 14
copper ores, iii., 1
Houstonia angustifolia, vii., 10; ix., 184
Croftiæ, vii., 10
humifusa, vii., 10
Hubbard, O. P., elected councillor, xii., 128
Hudsonian Godwit, bill of, vi., 30
Hudson River slate, v., 216
River Valley, clays of, xi., 33
Valley, boulders in, iii., 24–26
Valley, glaciation in, i., 25, 26
Human bones in caves, x., 10
milk, new fat in, ii., 140
remains at Inwood, N. Y., ix., 199
remains at Spy, viii., 132–135
Humasson, T. A., elected member, xv., 134
Humboldtilite in slags, iii., 104
Humidity of Panama, viii., 85, 86, 110

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Hungary, minerals from, iii., 104
opal mines of, xi., 32
Hunt, Dr. T. Sterry, death of, xi., 72
Huntington, George S., elected resident member, xii., 25
Huxley's bill to fix standard weights and measures, xv., 125
Huronian, xiv., 194
iron ores, ii., 6, 7, 17
Huron, shale of Ohio containing Dinichthys, iii., 20
Huxley memorial committee, xv., 39
fund, xv., 132
tribute, xv., 40
Hyaline quartz, viii., 161, 162
Hybrids and Hybridism, iv., 79
Hydatina, ix., 33
Hydnum septentrionale, v., 111
Hydraulics of the Mississippi, iii., 82–83
Hydrazoic acid, x., 43
Hydriodic acid, v., 187
Hydrochloric acid, v., 192
solidification of, v., 191
Hydrogen, v., 185, 186, 187
as primary matter, v., 184–185,
in comets, v., 255
in stars, v., 184
in sun, v., 245
liquefaction of, v., 190, 191
weight of atom of, v., 183
peroxide of, v., 188
Hydrodolomite, viii., 60
Hydromica schist, viii., 48, 50, 53
Hydrophane, vi., 111, 112; viii., 16, 17
Hydroxyl, v., 186
Hymænea, v., 137
Hymenatherum, viii., 77
Hymenatherum tenuilobum, vii., 11
pentachætum, ix., 182
tenuilobum, ix., 182
Hymenopappus Mexicanus, viii., 77
flavescens, ix., 184
Hyolithellus micans? xiv., 129
Hyolithes, cf. *princeps*, *Americanus*, *obtusa*, *decipiens*, *gracilior*, xiv., 129
Hyopotamus, xiii., 176
Hypericum virgatum ovalifolium (new), ix., 10
Hypotricha, ix., 34
Ice age in North America, ix., 83
caves in the Shawangunk Range, iii., 23
erosive power of, iii., 51–52
movement, direction of, iii., 24
crystals, x., 120
eroding, power of, viii., 164
period, theory of, ii., 157–159
Iced-Bar and Long-Tape Base Apparatus, xiii., 6
Iceland, geysers of, viii., 184
history of, viii., 184
people of, viii., 184
scenery in, viii., 184
spar, viii., 58
Ichthyosaurus, v., 26
Icterus Northropi (new), x., 52
Idaho forests, i., 5
mining, i., 4–5
volcanic tuffs, i., 49–50
minerals from, iii., 2, 72
Idocrase, ii., 25
Idunium, v., 200
Igneous rocks, v., 121–130, 222, 230
Ileo-colic junction of *Procyon lotor* xii., 50
Iles, Mr. George, elected resident member, xiv., 93
Illumination for Photo-Micrography, sources of, xiv., 71
Ilmenite, vi., 130; viii., 54
Ilysanthes gratioloides, ix., 185
Imperfections in rock crystals, v., 275–276
Implement shed, i., 121, 147
stone, i., 49, 85, 105
Implements of argillite, iii., 9
of flint of Amiens, iii., 80
Incandescence, Temperature, iv., 43
Inception and progress of railways, v., 137–152
Inclusions in amber, viii., 156, 157
in oligoclase, viii., 2
in quartz, viii., 21, 161
Index to Copernicus, x., 87
Indian arrow heads near Trenton, iii., 8
arrow heads in Oregon, iii., 63
mythology of Sacramento Valley, iii., 55
gold ornaments, vi., 40, 60
mounds, vi., 40, 71, 72
character, v., 203
garnets, v., 225, 226

Digitized by Google

Indian mounds, v., 73
remedies, v., 203
scraper, v., 72
wars, cause of, v., 203
corn, xii., 8
Indian Territory, copper region, i., 19-20
geology of, xv., 50
relations between the Carboniferous of Territory and Texas, xv., 50
Winslow's table of Succession, xv., 51
Dr. Chance's table of Succession, xv., 52
fuel ratios of coal, xv., 54
limestone of, xv., 52
Greenwood sandstone, xv., 53
Booneville stage, interest of, xv., 53
the Grady coal bed, xv., 53
the McAlister coal bed, xv., 54
Appleton and Danville stages, xv., 54
Appalachian structure of coal field, xv., 55
Limestone Gap, xv., 55
Condition along the Gulf, Colorado and Santa Fé Railroad, xv., 56
Buckhorn Creek limestone, xv., 57
Fossils in asphaltum, xv., 58
Collections by Prof. Hill, xv., 59
Ouachita Mountain system, xv., 59
Resemblance to Appalachian structure, xv., 60
Granitic area and Arbuckle Mountains, xv., 61
Indians, art among, viii., 116
tattooing among, viii., 116
Iroquois, ii., 57-61
skeletons at Far Rockaway, ii., 140-144
North American, food and fibre plants of, iv., 35
of Georgia and Florida, vi., 60-63
of South America, v., 227
Indigofera leptosepala, vii., 9; ix., 181
Indigo, v., 197
Indurated shales at Bergen Hill, N. J., iii., 7
Infant foods, ii., 95
Inferior planets, v., 247
Influence of vegetation in cities, etc., v., 264
Influence upon Science of the discovery of the New World, xii., 7
Infra-red Spectrum of the Sun, Researches in, xiv., 93
Infusoria, v., 49
"Infusiorial Earth" in New Jersey, viii., 16
Infusorian, phosphorescent, v., 15-16
Inoceramus, ii., 94; v., 133; ix., 31
Insecta, v., 42
Insects, fossil, at Florissant iii., 13
specialization of sex in, iii., 103
Inscriptions in Yucatan, v., 175-177
Instantaneous photo., vi., 42
Instinct in lower Vetebrates, xv., 126
origin of, xv., 123
Instrument for Quantitative Experiments, xiv., 163
Accuracy of, xiv., 167
Adjustment of, xiv., 166
Instruments, astronomic, v., 261
Ancient Astronomical, xi., 106
Interior of Earth, vi., 20-22, 29, 32, 33, 37
discussion, xiv., 86
Internal Ear, functions of, xii., 95
International Congress of Geologists, viii., 9, 21
Invitation from, xiii., 241
International time-system, i., 86-95
Intra-mercurian planets, viii., 154
Intrusive Rocks near St. John, N. B., xiii., 185
Inula submaxillaris, vii., 10
Inundations of the Mississippi basin, iii., 82-83
Invalid-foods, ii., 95
Invertebrate palæontology, x., 4
contributions to, x., 4
Invested Funds, management, xiv. 92
Ionidium lineare, vii., 7
polygalæfolium, vii., 12
Ipomæa hederacea, vii., 7
nil, vii., 12
trifida, vii., 12
Lindheimeri, ix., 185
Iris Missouriensis, viii., 80
Iron and steel, testing, i., 149
ores, i., 7, 162-163
Iron-apophyllite, viii., 57
disulphide, vi., 135
in meteorite, vi., 92

Digitized by Google

Iron ornaments from Indian mounds, v., 71–72
in Comets, v., 254, 255
meteoric, v., 74, 224, 227
ore, Cranberry Mine, v., 221
Staten Island, v., 229
magnetic, x., 59
meteoric, from Butte, Montana, ix., 205
meteoric from Pulaski Co., Va., ix., 205
meteoric from Turner Mound, ix., 193
meteoric from Kiowa Co., Iowa, ix., 190
Mine, Cornwall, Pa., xiii., 205
ores, ii., 64
crystalline, ii., 6–8
genesis of, ii., 13–17
of Iron Mountain, ii., 15
oxide from Pyrites, v., 192
in Staten Island, v., 229
Sands, concentration of, ii., 7–8, 14–17
Wire, curious corrosion of, iii., 65, 66
Iroquois Customs and Language, iv., 34
Indians, language, ii., 57–61
significance of flora to, v., 202
Irrigation, effect of, on climate, ix., 210
effects of, on rainfall, ix., 211
Ischypterus Agassizii, vi., 127
alatus, vi., 128
Braunii, vi., 128
elegans, vi., 128
fultus, vi., 128
gigas, vi., 128
latus, vi., 128
lenticularis, vi., 128
lineatus, vi., 128
macropterus, vi., 127
Marshii, vi., 127
micropterus, vi., 128
minutus, vi., 128
modestus, vi., 128
ovatus, vi., 127
parvus, vi., 127
robustus, vi., 128
tenuiceps, vi., 128
Islands, Hawaiian, x., 3
Isomerism, v., 197
Isotropy of egg, experiments on, xiii., 206
Is Palæospondylus a Cyclostome? xv., 100
Isthmian transit, viii., 165–173
Isthmus of Panama, viii., 85, 86, 168–172
termites of the, ix., 157
of Tehuantepec, viii., 165–173
Italy, ozokerite deposit, ii., 46, 47
Iulidæ, vi., 111
Ivesia depauperata, viii., 80

Jack, Robert L., elected corresponding member, xii., 40
Jacoby, Harold, elected Councillor, xii., 128
Jackson, A. V. Williams, elected secretary of sub-section of philology, xv., 5, 154
Jade, ix., 140–148; vi., 139–141
objects, vi., 141
ornaments from Oberstein, iii., 62
Jadeite, vi., 139–141
adze, vi., 139, 140
Japanese amber, viii., 157
crystal spheres, v., 233, 267–275
cost of, v., 273–275
cutting of, v., 270–274
size of, v., 274, 275
use of, v., 267–269
weight of, v., 276
Jasper, ii., 117
Jasperoid rock, viii., 180, 181
Jasperized woods, vi., 165, 166
Jatropha spatulata sessilifolia, ix., 181
Jay, Dr. John C., death of, xi., 32
resolutions on death, xi., 40
Jebel Nagous, viii., 182, 183; ix., 140
sonorous sand hill, iii., 98, 99
Jeff. Davis Mine, x., 63
Jefferisite, v., 77
Jersey City buildings, ii., 67, 71
Jesup, Morris K., elected member, xiii., 23
Jugateæ, xiv., 50
Joints in the Shawangunk conglomerate, iii., 23
Jones, C. N., elected resident member, xii., 40
Jouite, ix., 35
Journey in S. A., vi., 129, 138, 147
Judith River beds, ix., 29
Juglans, v., 136
nigra, iii., 107
rupestris, ii., 92; viii., 76; ix., 185

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Julien, A. A., elected Councillor, xii., 128
"Jumbo," v., 223
Juniperus, v., 136; vi., 124
hypnoidis, xii., 29
occidentalis, var monosperma, viii., 76
pachyphlœa, 76
Jupiter, v., 251
satellite of, xii., 27
surface marking of, xii., 218
Jurassic fossils, v., 19

Kaaterskill Creek and Clove, N. Y., i., 24-27
Kalinite, vi., 130
Kalmia Brittoniana, xii., 34
Kames in Catskill Mts., i., 27
Kamsin, ix., 114
Kane, S., Nicholson, elected resident member, xiv., 154
Kanai, sonorous dune, iii., 98
Kaolin of Long Island, viii., 179
of New Jersey, viii., 178
of Staten Island, viii., 178
Kapa, x., 27
Kauai, x., 28
Keir, Mr. James, viii., 23, 24
Kemp, James F., elected Librarian, xii., 128
elected fellow, xii., 39
elected resident member, xi., 25
Kerolite, v., 229
Kerosene oil, methods of ascertaining safety of, i., 137-143
Kerr, W. C., elected resident member, xiii., 151
Kew herbarium, viii., 3
Kidney of *Elephas Indicus*, xiii., 110
Kilauea, viii., 82
Kimberly Farm, Kan., view of the, ix., 186
Kingston Group, xiv., 209
sub-group, xiv., 193
Kiowa Co. meteorites, ix., 138, 186
analysis, ix., 190
map, ix., 188
weight, ix., 189
Kjeldahl method, v., 24
Kjockken moeddens, ii., 141-143
Knight, George H., elected resident member, xi., 25; xii., 218
Koch's method for development of bacteria, ii., 113, 114
Kootenai Lake, x., 57-61
Krakatoa, distribution of volcanic dust of, iii., 60, 61, 64, 65
microscopic examination of ash, iii., 14, 63, 64
eruption of, viii., 82, 83
Krameria lanceolata, vii., 8; ix., 183
Kunz, G. F., elected Curator, xii., 128
Kyanite in Mica schist, iii., 22; v., 75, 222

Labiatæ, vii., 13
Laboratories, marine, xii., 95
Laccolite elevation in San Juan Mts., v., 129
Lactuca pulchella, viii., 80
Lake Champlain, colored marbles, iii., 100
at High Point, N. Y., iii., 29
Mœris, Egypt, Survey at, iii., 78, 79
Mohawk and Minnewaska, N. Y., iii., 27-30
Nicaragua, species of skate in, iii., 38
at Sands Point, N. Y., iii., 26
Superior, ancient mining excavations at, iii., 14
Copper series at, iii., 13, 14
first steamboat on, iii., 13
ores, iii., 1, 2
Lakes, artificial, viii., 117-125
Lake Kootenai, x., 57-61
Champlain valley, trap dikes in, xi., 13
Champlain geology of, xv., 19
Champlain, petrography and distribution of trap dikes in the region of, xv., 105
Lamborn, Robert H., memorial, xiv., 12
Lamna, ii., 85
cornubica, vi., 70
Lamp, arc, x., 104
Land and people of Paraguay, xi., 24
Land shells of Curacao, Buenos Ayres and Aruba, ii, 151-154
Porto Rico, 150
"Landskibet," vi., 93
Language of Iroquois Indians, ii., 57-61
and customs of the Iroquois, iv., 34

Digitized by Google

Language of ancient Egyptians, iv., 60
Lantana camara, vii., 13
Lantern Hill, Mystic, Conn., great quartz vein of, xv., 183
microscope, iii., 105
projections, x., 103
Lapidary work at Oberstein, iii., 62
Lapis lazuli, ix., 148
Laguna Beach, x., 32
Laramie City, Wyo., calcite crystals, iii., 7, 19, 20
flora, x., 3
group, ix., 27
relation of, to the Puerco, xii., 69
Larrea Mexicana, ii., 92; ix., 181
Larvæ, classification of Lepidopterous, xiii., 161
of Limulus, ii., 106–107
Lathyrus Arizonicus, viii., 65
Latitude, determination of, v., 235
variations of, xii., 26
Laumontite, ii., 89; vi., 129
Luray Cavern, ii., 38–41; v., 217
Laurencite, in meteorite, vi., 161
Laurentian formation, ii., 7
iron ores, ii., 7, 8, 14–17
rocks, v., 216
rocks of S. E. Penna., viii., 48–51
of Westchester Co., N. Y., viii., 52
rocks, notes on, xiv., 21
series, xiv., 192, 194
Laurus Hollæ, xii., 34
plutonia, 236
primigenia, 33
Lava caves, ii., 36
plain in Idaho, i., 4–5
Lavœsium, v., 200
Law of deflection in steel rails, xv., 147
Laws of fatigue, etc., vi., 114–121
Lawrence, Mr. George N., xiv., 71–72
Lawton, James Marsland, Jr., elected member, xv., 34
Lead disulphate, xiv., 5
native, i., 3
oxide, i., 3
native, iii., 2
red oxide, iii., 2
sulphide, iii., 2, 23
Lea, Dr. Isaac, memorial of, vi., 65
Leaf-bearing sandstones at Glen Cove, L. I., iii., 30–31
Leaf forms, origin of, iii., 38–49
Leaf impressions in "Amboy" clays, v., 136
Lechea, xii., 188
Lecture course, programme, i., 95
Lecture experiment, v., 214, 215
Lectures, public course, viii., 59, 82, 114, 130, 151, 163; ix., 55, 71, 83, 104, 127, 133, 139, 156, 200
Lederle, Ernest, elected resident member, xi., 25
Leeches Excreting, System of, xiv., 79
Lee, Frederick S., elected resident member, xii., 25
Leersia oryzoides, ix., 14
Virginica, ix., 14
Leguminosæ, vii., 9
Leguminosites frigida, xii., 34
Leis, x., 27
Lembke, Charles F., elected resident member, xiv., 154
Leucophyllum Texanum, vii., 12
Lenum Berlandieri, vii., 8
multicaule, vii., 8
Lenses, glass, vi., 96–103
Lentinus Lepideus, v., 111–113
Lensites vilas, v., 111
Lepachys Columnaris pulcherima, ix., 184
Lepidium intermedium, vii., 7
Lepidoptera, v., 44
Lepidosteus, vii., 257
LePlengoon, Dr., discoveries in Yucatan, v., 173, 175, 178
Leopardite, v., 222
Leptæna, vii., 2
Sericea, vii., 4
Leperditia (?) *ventricosa, Steadi, minor, primæva*, xiv., 137
Lepiditta sigillata, xiv., 138
Lepidodendrum, iv., 75, 76
Lepidolite, v., 80
Lepidoptera, a list of, ix., 2
Lepidopterous larvæ, Classification of, xiv., 47
Lepidosteus, vii., 257
breeding habits of, xiv., 45
Leptæna, vii., 2
sericea, vii., 4
Lespedeza, North American species of, xii., 57
Leucite in New Jersey, xiii., 144
Leucophyllum Texanum, vii., 12
Level of N. J. Coast, vi., 39

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Levine, Edmund J., elected resident member, xv., 147
Lexell's Comet, history of, x., 110
Leytter, Emile, elected resident member, xv., 147
Liatris punctata, vii., 10
Libbey, Jr., Prof. Wm., elected corresponding member, xiii., 171
Libocedrus decurrens, iii., 85
Librarian, vi., 1, 109–167
report, iii., 70; viii., 126, 127; ix., 3, 56, 107; xiv., 90
Librarian's report, xv., 132
Exchanges added, xv., 132
Requests for publications, xv., 132
Librarian's expenses, xv., 133
Library, accessions to, viii., 4, 29, 175, 184
Library of Academy, condition and increase, iii., 70
removal, iii., 106
Library of Academy, v., 1, 20, 164, 282
Library, Academy by law, vi., 1
transfer of, vi., 12, 109, 110
accessions, vi., 109
exchanges, vi., 167–182
Library, disposition of, iv., 46
Lichens, attack on Stone, ii., 123
Life of Arnold Guyot, iii., 66–88
Benjamin N. Martin, iii., 56–60
building stones, in New York, ii., 136
Mr. Thomas Bland, v., 29, 278
Dr. A. C. Post, v., 280
Triassic, vi., 124–128
Light, arc, x., 103
oxhydrogen, x., 104
electric, v., 97–102
Lightning, protection from, xiii., 111
Lignite, ii., 86; v., 230; ix., 35
in "Amboy" clays, v., 136
Ligusticum montanum, viii., 80
scopolorum, viii., 78
Likeness of Dr. Priestley, viii., 17–20
Liliacea, vii., 14
Limax agrestis, xiii., 136
Limestone, i., 15–19, 22, 58
erosion of, i., 60 65
ii., 11, 16, 25, 69–72, 85, 95
caves in, ii., 36–41
durability, ii., 128, 136, 137
eocene, near Green River, iii., 13
pebbles, curiously grooved, iv., 2
v., 222
at Natural Bridge, v., 218
beneath Trias of New Jersey, v., 19
in San Juan Mts., v., 125, 126
overlying "Dakota," v., 133
stains and decay in, v., 62
of Staten Island, vi., 13–15
of N. J., vi., 59
of Illinois, vi., 137, 138
Limit to economical expansion in steam engines, ii., 1
Limnanthemum lacunosum, iii., 43
aquaticum (new), ix., 121
Limonite, ii., 7, 14–17; iii., 18; v., 229, 230; vi., 16, 17, 70, 71; viii., 54, 60
of Staten Island, viii., 180, 181
from St. John's River, xiii., 22
Limulus, ii., 8; xii., 241
larvæ of, ii., 106–107
polyphemus, ii., 106–107
eggs of, iv., 5
Linaria Canadensis, vii., 12
Lineæ, vii., 8
Lingual dentition of pulmonate molluscs, iii., 71
Lingula Quebecensis, vii., 2
Lingulella (?) *cælata*, *inflata*, *ovalis*, xiv., 126
martinensis cf. granvillensis, xiv., 113
Linum Berlandieri, vii., 8
multicaule, vii., 8
Linnarssonia transversa, xiv., 125
Lip ornaments, ix., 153
Lippia lanceolata, ix., 185
ligustrina (new), ix., 181, 185
lycioides, ix., 181
Liquefaction of gases, v., 190–191
Liquidambar, iii., 47
Styraciflua, iv., 31
Liriodendron, iii., 41, 94; v., 136
Liriodendron, xiii., 133
simplex, xii., 33, 232; xiii., 130, 180
primævum, xii., 35
List of Contributors to Publication Fund, iii., 112
Corresponding Members, iii., 126–137
Honorary Members, iii., 123–125
Patrons of the Academy, iii., 113
Resident Fellows and Members, iii., 114–122
Subscribers to old Building Fund, iii., 109–111

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List of Exchanges, vi., 167–182
species of Band b (Protolenus Fauna), xiv., 148
State and local floras, ix., 108
Literature, Astronomical, v., 261–262
of Electrolysis, i., 163
of Ozone, iii., 34
"Lithia Emerald," viii., 161
Lithium Bichromate, in Golgi staining, xiii., 206
Lithology of N. Y. Island, viii., 53–55
of S. E. Penn'a, viii., 47–51
Lithomarge, vi., 3
Lithospermum canescens, vii., 12
Lithostrotion microstylum, vii., 247
Little Bahama Bank, x., 4
"Little builders of the Earth," viii., 151
Living matter, structure of, ii., 79–84
Livonia salt well, ix., 41
Lobelia Clifforteana brachypoda, ix., 185
Local Com., A. A. A. S., vi., 129, 130
Lochs and crannogs of Scotland, xi., 48
Locomotive, capacity of, v., 144, 145, 152
combustion in, v., 144–146
development of, v., 138–143
fuel necessary in, v., 144–146, 150
speed of, v., 143, 144
weight of, v., 145, 152
Locomotion of animals, i., 164–167
Loeb, Morris, elected resident member, xii., 1
Loelaps, iii., 53
Loess formation, fossils of, iii., 14
Long Island and Nantucket, xv.,
Cretaceous material in the Moraine, xv., 5
Marine Cretaceous, xv., 3
yellow Gravel, xv., 5
Cretaceous of, viii., 177, 181
Geology of, iv., 25
Geology of North Shore of, xiii., 122
Longitude, v., 235
Lonicera involucrata, viii., 80
Loperia simplex, vi., 126
Louisiana cane juices, etc., ix., 108
Love, E. G., elected member, xv., 134
Lower Niagara limestone, certain crinoidea of, ix., 139
Lower Silurian Strata, v., 216
Lowest temperature, v., 191
Loxoclase feldspar, ii., 147
Lumbricus, xiii., 135
Lumeniferous ether, v., 77
Luminous limestone from Utah, iii., 100
Lunar craters, xii., 93
photographs, xii., 26
eclipse, photographs of, xv., 63
'Society,' viii., 23, 24
surface, changes on, xi., 42
Lupinus subcarnosus, vii., 9; *rivularis var. latifolius*, viii., 80
Luquer, L. McI., elected resident member, xii., 25
Luzula spadicea var. parviflora, viii., 78
Lycopodium dendroideum, iii., 47
Lygodesmia aphylla, vii., 11; ix., 184
Lyrodesma pulchella, vii., 4
Lythrum alatum, ix., 181–184
alatum linearifolium, ix., 181

Macadam pavements, viii., 43
Machairodus, iii., 53
Mackintosh, J. B., viii., 9, 185
Macroceramus, ii., 152, 153
Gossei, ii., 152
inermis, ii., 152
Macrotus waterhousei, x., 52
Mactra alta, ix., 31
Macy, Chas. A. 2d. elected resident member, xiv., 154
Madonna mine, Colorado, v., 130
Madrepora cervicornis, x., 7, 20
palmarum, x., 20
Mæandrina, x., 7
'Magic Stone,' vi., 111, 112
Magnesian limestones, v., 216
Magnet Cove, Ark., perofskite, iii., 17
Magnetic Circuit, xv., 97
Magnetic iron, x., 59
storms, v., 240
Magnetism of earth, v., 240
Magnetite, ii., 7, 8, 13–17, 94; iii., 17, 18; vi., 130–162; viii., 54–59
of Gunnison, Colorado, i., 7
in New York Island, v., 232
Magnitudes, star, x., 117
Magnolia, iii., 47, 84, 85, 94, 96; v., 136

Digitized by Google

Magnolia alternans, xiii., 181
Capellini, xii., 234
ongifolia, xii., 36
speciosa, xii., 234
glauca, iv., 31
Maine, minerals from, iii., 2
Majanthemophyllum pusillum, xii., 36
Major Planets, v., 250–253
Malachite from Arizona, v., 19
from N. Y. City, vi., 41; viii., 12, 45, 59; ix., 143
Malpigiacea, vii., 8
Malvaceæ, vii., 8
Malvastrium, viii., 77
Americanum, ix., 181
tricuspidatum, ix., 181
Mammalia, genealogy of, v., 89
the rise of, xii., 53
Mammalian fauna of Lower Miocene, xii., 50
Mammals, Cretaceous, recently discovered, xii., 27
from White River Deposits, Dak., xiii., 176
Mammoth cave of Kentucky, i., 59–66; ii., 38–41
extinction of, iv., 19, 23, 25
Siberian Skin of, iv., 24
Menaccanite, ii., 7
Man, antiquity of, iii., 7–12
Manchester, Mass., "singing beach" at, iii., 73–75
Manganese, x., 59
Manganese ore in southwest Virginia, i., 163
oxide, ii., 14, 17, 100; vi., 91
Mangroves, x., 6
Mann, Charles Riborg, elected resident member, xi., 40
Man of Spy, viii., 132–135
Manufacture of stone tools, x., 110
Maple juice, sap-sand, i., 168
sugar, artificial, v., 194
Map of U. S., construction of, viii., 21
Marbles, colored, ix., 95
from Manchester, Vt., ix., 96
from Numidia, ix., 95
of the ancients, iii., 101, 102
of Virginia, i., 163
Marble, decay of, ii., 38, 71, 72; v., 62–69
durability of, ii., 128–133, 136
flexibility of, ii., 130–133
quarries of Western N. E. and Eastern N. Y., xv., 182
Marcasite, v., 231; viii., 54
in Mica, v., 121
Margaritana, viii., 163
Margarops albiventris, vi., 111
Marginal modifications of the leaf, iii., 39–41
Marié, Peter, elected resident member, xiv., 154
Marine Laboratories of Europe, xii., 95
Marl belt of New Jersey, ii., 9–13, 85
Marmolite, i., 58; v., 229
Marrubium vulgare, ix., 185
Mars, v., 249–250
Marsh gas, v., 190
Marsileaceæ, vii., 14
Marsilea macropoda, vii., 14
Martha's Vineyard, Geology and Botany of, xiii., 8
Martin, Benj. N., life of, iii., 56–60
Martin, D. S., elected Councillor, xii., 128
Massachusetts, minerals, iii., 17, 18
Mastodon, iv., 20, 22; vi., 59; vii., 52, 128, 246
remains, v., 15, 117, 223
tooth, viii., 2
Mauna Loa, viii., 82
Maximowiczia Lindheimeri, vii., 9
Maya inscriptions and carvings, v., 170–178
Mayer, Prof. A. M., elected resident member, xiii., 234
McLouth, Lawrence A., elected resident member, xv., 147
Meandrina convexa, vii., 253
Mearns, Dr. E. A., viii., 60
Measurements of air effects, xiv., 169
Measures of Stars about Beta Cygni, xi., 120
Mechanical power from electricity, v., 102–110
from heat, v., 95–97
into electricity, v., 94–97
science, researches in, ii., 18
Medicago Virginica, xii., 58–64
Medical knowledge of Indians, v., 203
Medina sandstone, v., 216
Mediterranean, amber of, viii., 157
Medusæ, v., 37

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Meeting, annual, ii., 95–100
of National Academy of Sciences, xi., 41
Meetings of Academy, v., 162
annual business, xv., 128
extra, xv., 123
business, xv., 1, 34, 97, 123, 128, 134, 147, 155
stated, xv., 1, 3, 39, 50, 62, 66, 70, 98, 104, 125, 127, 137, 143, 146, 148, 153, 154, 157, 182
Megaceros, xiii., 180
Megalosaurus, iii., 53
Melamine, v., 195
Melampodium cinereum, vii., 11; ix., 184
Melanterite, stalactitic, viii., 22
Melastomaceæ, iii., 41
Melica diffusa nitens, ix., 185
Melochia pyramidata, ix., 181
Melosira, ix., 35; xii., 220; xiii., 181
Members, election of new, i., 77, 105, 129, 150, 158, 163, 176, 180
deceased, i., 77, 108, 158, 159, 164
election, ii., 24, 42, 62, 79, 100
resignation, ii., 9, 42, 57, 62, 154,
decease, ii., 2, 36, 67
corresponding, election of, iii., 1, 18, 32, 37, 48, 72
decease, iii., 2, 33, 37, 56, 66, 80
election of new, iii., 1, 18, 31, 32, 37, 48, 55, 71, 72, 80, 100, 106
resident, election of, iii., 31, 55, 71, 80, 100, 106
resignations, iii., 34, 37, 48, 55, 62, 72, 103
of Academy, decease of, v., 29, 278–281
election of, v., 9, 25, 80, 110, 137, 169, 213, 232, 277
number of, v., 162
honorary, supplement, x.
corresponding supplement, x.
resident supplement, x.
Membership lists, viii., 209–230
Memorial Notices, v., 17, 29, 278–281
Memorial of Mr. B. B. Chamberlain, viii., 46–47
of Prof. G. H. Cook, ix., 75
Dr. John I. Northrop, xi., 9
Memoirs and Annals, xv., 133
Memoirs of Columbian Chemical Society, xi., 57
Meneghini, Guiseppe, death of viii., 4
Menganthis trachysperma, ix., 12
Menodora hetherophylla, vii., 11
Mentzelia lœvicaulis, viii., 79
Mercury, native, viii., 22
ores, ix., 149
(planet), v., 248
Merismopedia rosea, xiv., 94
Merulius lachrymans, v., 110, 111
Mertensia paniculata, viii., 78
Mesabi Iron Range of Minnesota, xiv., 47
Mesohippus, vii., 158, 190
Mesoplacentatia, xiii., 175, 254
Mesozoic coal-plants from China, ii., 151
Metallic tin, crystals of, xi., 96
Metals, use by Indians, vi., 60–65
Metallurgic astronomy, ii., 53–54
Metamorphic rocks in Colorado, v., 125–129
rocks of Staten Island, vi., 12–16
Metamorphism, xiv., 203
Metastelma Carbigerum, vii., 11
Meters, electric, x., 118
Meteoric iron, v., 74
aboriginal use, v., 227
from Augusta County, Va., v., 224
Meteoric iron, ix., 97
analysis of, ix., 195, 197, 198
analysis of mass, ix., 202
analysis of nickel iron, ix., 202
analysis of siliceous part, ix., 202
Bridgewater, N. C., ix., 194
Butte, Montana, ix., 205
Colfax, N. C., ix., 197
diagrams, ix., 195, 196
Ferguson, N. C., ix., 198
Pulaski Co., Va., ix., 205
Summit, Ala., ix., 196
Winnebago, Iowa, ix.. 201
stone, Kansas, xv., 185
Meteorite, from Cabin Creek, vi., 141–146, 166
Catorze, Mex., vi., 76
Germany, vi., 35
Kentucky, vi.,71–76
Mazapil, Mex., vi., 71, 92, 144, 146
Powder Mill Creek, vi., 161, 162
Tennessee, vi., 160, 161

Digitized by Google

Toluca, Mex., vi., 70
from Kansas, xii., 96
of Alfianello, ii., 117
containing Olivine, iv., 5
from New Mexico, iv., 77
from Laurens Co., N. C., iv., 80
from Catorce, Mex., v., 227
from Cohahuila, v., 231
from Texas, v., 231
in southwest Pennsylvania, v., 14
Meteorites, decomposition of, v., 231; vi., 143–146, 160–162
from Kiowa Co., Kan., ix., 138, 186
from Texas, viii., 186
from Tennessee, viii., 187
fusion-structures in, i., 153–155
stone, vi., 71
Meteorological Notes in Curacoa, iv., 47
Meteors, iv., 256–257
Method, Kjeldahl, x., 24
von Asboth, x., 25
of defining standard colors, xiii., 170
Methods of analysis, ii., 26-35
of animal locomotion, i., 164, 167
of animal self-defence, iii., 53–55
of deducing motions of fifty-six stars, etc., xiv., 68
of research in bacteriology, ix., 139
Methylene, v., 196
Metric system, introduction and adoption of by Government and the country, xv., 124
Mexican amber, viii., 158, 162
aragonite, viii., 44
tin ore, viii., 150
idols, ix., 97
natives, v., 130
Mexico, minerals, iii., 38, 63
Meyer, Thomas C., elected resident member, xiv., 154
Mica, ii., 3, 147; v., 232; vi., 3, 39
slate, ii., 73
containing marcasite, v., 121
in Ohio mounds, v., 73
in Roan Mountain, v., 222
mines of, v., 73, 222
mines of in North Carolina, v., 222
mirrors, v., 73
schist, holding Kyanite, iii., 22
schists, v., 222
Micaceous mineral from Franklin, N. J., xiii., 97
Michigan minerals, iii., 1, 2
Michilinia expansa, vii., 247
placenta, vii., 247
Micmacca Matthewi, var Ingeni, recurva (?) *plana*, xiv., 141, 142
Microcline in Granite Diorite, xiv., 84
Microdiscus, not in Protolenus Fauna, xiv., 150
Microscopical technique, xii., 56
Microscopic examination of ores, ii., 34
observations, errors in, ii., 81–83
examination of sand, iii., 64, 75
examination of volcanic ash, iii., 63, 64
structure of a conifer, iii., 87
organisms in the clays of New York, xiii., 165
Milk, human, new fat in, ii., 140
Mimocichla plumbia, x., 52
Mimosa fragrans, ix., 184
Linotheimeri, ix., 184
malacophylla glabrata, ix., 181
Mimulus floribundus, viii., 79
Mimus polyglottis, x., 52
gundlachi, x., 52
Mineral Cabinet, On a portable, xiii., 140
resources of southwest Virginia, i., 159–163
wax or ozokerite, ii., 43–50
Mineralogical Journal, Bruce's American, xi., 57
names, origin and history of, xi., 49
notes, v., 223; xiii., 144, 184
Mineralogy, local field-work on New York Island, iii., 48–50
Minerals from Arizona, viii., 11, 12, 13
from Bergen Hill, N. J., viii., 16, 17
from California, viii., 22
from Colorado, viii., 12, 160
of French Creek, Penn., iv., 41; viii., 56–59
of New York Island, v., 120–121; vi., 130; viii., 2, 3, 21
of North Carolina, viii., 2, 7, 8, 160, 161
of Stoneham, Maine, viii., 12, 13

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Minerals from the West. v., 213, 214
interesting, etc., v., 131–133
of Harlem, v., 74–77
of Staten Island, v., 228—230
gems and Ethnology of the Ural Mts., xi., 119
new species of, viii., 8, 9, 185
of the Desert of Sinai, ix., 124
exhibited at Paris, 1889, ix., 145
of Weehawken tunnel, i., 129–131; ii., 88–90
Mines in San Juan Mts., v., 122
Mining, Chihuahua, ii., 94, 95
ozokerite, ii., 43–50
excavations, ancient, iii., 14
Idaho, i., 4–6
Montana, i., 4–6
Nevada, i., 7, 172–175
Southwestern Colorado, i., 7, 8
Utah, i., 168–172
Miocene, a new artiodactyl from, xii., 50
Mammalian fauna of lower, xii., 50
Deposits of White River Group, xiv., 187
Mammals, Restoration of, xiii., 110
Miohippus, vii., 158, 159, 190
Mississippi, basin of, viii., 170
entrance to, viii., 171
River commission plan of, iv., 43
River, hydraulics of, iii., 82, 83
Mitchell's Geology of North Carolina, xi., 45
Mitigated virus, theories of, v., 204–213
Mme. Gorgnet, will of, xi., 2
Modern Medicine, contributions of organic chemistry to, xi., 107
Mogollon Mts., flora of, viii., 60–81
Moisture, as erosive agent, ii., 4
Molecular formulæ, v., 195–197, 199
theory, v., 199
Mollusca, v., 32. 34, 42, 47, 49, 52
Molybdite, vi., 130
Molybdenite, vi., 130; viii., 50
Molybdenum, v., 128
Monadites, xiv., 112
Monarda clinopodiodes, vii., 13
citriodora, ix., 185
Monazite from Maine, ii., 42
Monobromphenole, iii., 32
Monodon monoceros, xii, 50
Monograph of Scyonotus, xiii., 169
Montana forests, and mining, i., 5
Geology of Northern, iv., 2
Montclair, N. J., cavities in Quartz from, xiii., 184
Monticellite, x., 70
and Perofskite from Magnet Cove, xiii., 139
Montivaltia Atlantica, ii., 12
Monument to Audubon, vi., 163, 164; viii., 128
Moon, v., 237, 238, 553
heat from, v., 238
motion of, v., 237
surface of, v., 237
horizontal enlargement, i., 116–118
photographs of, i., 143–145
Moonstone, iii., 107; viii, 162
Moraine materials in Sullivan County, N. Y., iii., 25, 26
Moraines in British America, viii., 164
in Colorado, viii., 164
on Staten Island, v., 230
Moral bearing of recent physical theories, i., 96–99
Morgan, J. Pierpont, elected resident member, xi., 25
Morgan, Prof. C. Lloyd, elected corresponding member, xv., 63
Moriconia, v., 136
Morphology and Physiology of Pancreas cell, xiii., 176
Morus microphylla, viii., 76
"Mosaic agate," viii., 44
chronology, iii., 11
Mosandrum, v., 200
Mosasaurus, ii., 11
Moses, Alfred J., elected resident member, xii., 25
Mosques of Constantinople, iv., 44
Motion for arrangements for second Annual Reception, xiv., 48
Motion of 61 Cygni, xiii., 120
Motions of amœbæ, ii., 82
Mound at Circleville, Ohio (cloth from), iv., 5
builders, i., 121, 122; ii., 41; iv., 48, 49; x., 42
Mounds and mound builders of Ohio, xiv., 67
animal, x., 40
Indian, v., 73
of Ohio, discoveries in, iii., 97

Digitized by Google

Mountain leather, iii., 49
of the Bell, viii., 182, 183
Mountains, formation of, vi., 23, 24, 28
their origin and history, xi., 45
Mount Antero, Col., minerals of, viii., 12, 160
Mount Morris, x., 59
Moyes, Dr. Henry, viii., 23
Muhlenbergia, viii., 79
Wrightii, viii., 79
Mummied fishes, xiv., 63
Mural carvings in Yucatan, v., 170–178
Muscidæ, calyptrate, xi., 131
Muscle brachio-ulnaris medialis, xiv., 252
lateralis, xiv., 248
combinations, xiv., 249
complete type form of, xiv., 235
coraco-epitrochlearis, xiv., 251
coracoid heads, xiv., 258
coraco-radial, xiv., 236
coraco-radial and coraco-ulnar, xiv., 238
coraco-radial and gleno-ulnar, xiv., 238
coraco-ulnar, xiv., 236
coraco-ulnar head, xiv., 250
glenoid heads, xiv., 257
gleno-radial, xiv., 236
gleno-radial and coraco-radial, xiv., 237
gleno-radial and gleno-ulnar, xiv., 237
gleno-ulnar, xiv., 236, 243
gleno-curaco-ulnar, xiv., 238
gleno-ulnar, head, xiv., 241
relation of biceps, xiv., 254
exhaustion of, vi., 114–121
refreshment of, vi., 118
Muscovite, ii., 147; iii., 49; vi., 3, 39; v., 232
from Colorado, v., 133; viii., 55, 145
Museums of Europe, viii., 11
Museum of Natural History, v., 266
Musical sand, viii., 9, 10, 182, 183; x., 28
in California, x., 31
at Coronado Beach, x., 31
at Laguna Beach, x., 32
in Mexico, x., 32
at Monterey, x., 32
at Pescadero, x., 31
at Redondo, x., 31
at San Francisco, x., 32
at Santa Barbara, x., 31
theories of, x., 33
pitch, xii., 69
Mus rattus, x., 53
Mussels and mussel culture, iv., 3
Mustela, xii., 51
Mycelium of fungi, v., 72, 111–119, 217
Mycoderma cerevisiæ, vi., 68
Mylostoma, ii., 145; xii., 70
variabilis, n. sp., ii., 146
Terrelli, n. sp., ii., 147
Myrica Davisii, xii., 32
grandifolia, xii., 32
Myriophyllum ceratophyllum, iii., 46
Myriopoda, xii., 138
Myrtophyllum Geinitzii, xii., 236; xiii., 130
Myths, Chaldean, ii., 106–110
Mythology, Indian, of Sacramento Valley, iii., 55
Mytiloconcha incurva, ix., 88
Mytilus edulis, iv., 5; ix., 33

Naïs, ix., 33
"Nameless" (new element), v., 200
Nantucket, xv., 3
amber, ii., 85
character of moraine material, xv., 7
general remarks, xv., 6
palæontology, xv., 7
mollusca, xv., 8
crustacea, xv., 9
Naples and its surroundings, xii., 188
Nash, Stephen P., elected resident member, xi., 40
Nasua, xii., 51
Nasutitermes (new), ix., 158
destructive power of, ix., 161
"Nasuti" termites, viii., 90, 9 104–111
Natchez Indians, vi., 42, 60–65
Natica, ii., 26
National Academy of Sciences, viii., 21, 175, 176
meeting of, xi., 41
report on meeting, xiii., 120
National Board of Health, v., 263
Museum, vi., 166

Digitized by Google

Native gold, viii., 7, 139, 140, 160
mercury, viii., 22
silver, viii., 11, 160
iron in basalt, iii., 104
Natrolite, ii., 89; ix., 143
from Weehawken, N. J., i., 130
Natural Bridge, Virginia, v., 218
dyes as applied to wool, xi., 48, 157
Flora of Bronx Park, xv., 62
history, bibliography of, x., 71
science, teaching in schools, ix., 37
Natural Science Association of Staten Island, viii., 177, 178
Field day, iv., 5
Nautilus, ii., 94; viii., 115
De Kayi, ii., 12
Navicula, ix., 35; xii., 220; xiii., 101
viridis, vi., 50
Neanderthal skull, viii., 21
Nebulæ, v., 260
and the nebular hypothesis, ix., 133
Necronite, viii., 21
Needle Mountains in Colorado, v., 122
Need of normal time, etc., v., 158–162
Negundo, iii., 41
Neith (supposed planet), v., 249
Neithea Mortoni, ii., 10
Neodimium, v., 185–200
Nephelis, classification of, in the U. S., xv., 66
funnels and vesicles of, xiii., 206
Nephridial structure of, in Clepsine, xv., 126
Neptune, v., 253
Neptunium, v., 200
Netsinker Indian, from Manhattan Island, xii., 17
Nevada, black marble, iii., 101
minerals, iii., 72
sonorous sand-hill, iii., 99
mining in, i., 7
pumice tuff, i., 51
sulphur deposits, i., 172–175
New beetle, viii., 117
Newberry, John Strong, memoir of, xii., 152
bibliography of, xii., 173
New Brunswick, volcanic rocks, xiv., 216
New chemical products, v., 192
organic, v., 194–197
cladodont from Ohio, Waverly, xiii., 115
New Durham, sandstone of, ii., 117–120
"New earths," v., 200
New elements, v., 181–200
form of Bunsen battery, x., 114
forms of Coccosteids, xiii., 176
forms of Wollastonite from N. Y., xiii., 146
fungus on silicified wood, xiii., 201
method of making fine bolometer, xiii., 171
protecting houses from lightning. xiii., 171
minerals, described, viii., 8, 46, 56, 185
plants from Arizona, viii., 65, 71, 72, 73
from South America, viii., 3
red sandstones, v., 12
sphermophile, viii., 41
species of bird, v., 17
from Yucatan, v., 55
species fossil fishes, v., 333
substances, v., 194–199
Newfoundland, Cambrian of, viii, 176
New Jersey, amber, ii., 13, 85–87
franklinite ores, ii., 26–35
marl-belt, ii., 9–13, 85
shell mounds, ii., 143
copper ores in, iii., 18, 19
gravels at Trenton, iii., 7–12
minerals of, iii., 2, 18–19, 50, 78
sorghum industry in, iii., 5, 6
Cretaceous of, viii., 47, 178, 179
preglacial and glacial drift, iv., 26
New Mexico, honey ants of, iii., 103
floral characters of, viii., 76–81
table land of, viii., 77
Newport, R. I., Carboniferous area at, iv., 76
New Providence, x., 5
New York and Brooklyn bridge ii., 72
building stone, ii., 67–70, 120–138
City and neighborhood physical geography, xv., 123
city water supply of, viii., 117–125
New York County, minerals of, viii., 2, 3
New York, drift hills, i., 77–80

Digitized by Google

New York glaciation, i., 24–31, 57
gold deposits, i., 1
Island, glaciation, i., 30
Laurentian age, i., 57
Island, mineralogy, iii., 22, 48–50
Island, rock exposures on, x., 113
Mineral Club, vi., 160
Mineralogical Club, viii., 8, 46; ix., 140, 208
State Forestry Association, ix., 97; viii., 37, 38–40
Minerals, iii., 22–23, 34, 48–50
Obelisk, xii., 188
State Medical Association, viii., 16
New Zealand, minerals of, xv., 185
Niagara, Preservation of Falls, iv., 54
Nicaragua canal-route, viii., 165, 168, 169
Nicholson pavement, v., 116, 120
Nickel, in meteorite, vi., 92
Metallurgy of, v., 192
Mines at Lancaster, Pa., xiii., 205
Nicotiana attenuata, i., 8
repanda, vii., 12; viii., 12
Nicotine, v., 195
Nierenbergia anomala, vii., 12
Nile, scientific jottings on the, ix., 110
physical geography of, ix., 116
temperature on the, ix., 111
rain-fall on the, ix., 113
Nitric acid, v., 188, 193
oxide, v., 190
Nitrogen, v., 185–195
liquefaction of, 190, 191
Nitrous oxide, early experiments with, viii., 15, 16
Nœggerathia, iii., 47
Noctiluca, v., 15, 16
Nocturna, xiv., 56
Nohili, x., 29
Nomenclature, Chemical, v., 179, 180, 193
Nominations of officers, x., 57
Norites, xii., 71
Normal time system, v., 158–162
North America, ancient glaciation in, ii., 155-159
Caribs in, ii., 142
alternations of temperature, iii., 96
exhaustion of soil, iii., 16, 17
glacial epoch in, iii., 102
glacial erosion in, iii., 51, 52
singing braches of, iii., 72–76
skill of prehistoric races of, iii., 15
Cretaceous flora of, v., 133–137
North American amber, viii., 157, 158
North Atlantic Ocean, Age of, v., 77–79
North Carolina, emeralds, i., 101–105
fluid bearing quartz crystals, i., 131–136
stone implement, i., 85
amber, ii., 86
gold, ii., 79
ores, ii., 149, 150
minerals, iii., 12, 13, 37, 38, 50, 53
gold of, viii., 139, 140
minerals of, viii., 160, 161
tin deposits of, viii., 136–151
Northrop, Dr. John I., obituary notice, x., 120
death of, xi., 1
memorial of, xi., 9
North Pole, discovery of, i., 46–48
Norwegian glaciers, amount of erosion by, iii., 52
Norwegium, v., 200
Notation, chemical, v., 102, 106
Notes, chemical, v., 200–202
geological, etc., v., 215–223
mineralogical, v., 223
on local mineralogy, v., 121
on minerals from the West, v., 213, 214
on the gold cure, xi., 151
on a nickel mine at Lancaster, Pa., xiii., 205
Trip in Oaxaca, Mex., xiii., 204
Trip to Cornwall Iron Mines, xiii., 205
petrographical, xi., 156
Nothoscordum striatum, vii., 14
Notice of fossil fishes (title), v., 281, memorial, ix., 75
Notices, coleopterological, No. III., xi., 2; No. IV., xi., 125
Nova Scotia stone, durability of, ii., 124–125, 136
Novus orbis, vi., 60
Nucleolites crucifer, ii., 12, 13
Nuggets of gold, ii., 79
Nugget of silver in Arizona, xv., 191

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Numismatics, contributions of alchemy to, ix., 71
Nuphar parvulum, iii., 43
Nutation of earth, vi., 92, 133, 134
secular changes, vi., 131–134
Nyctagineæ, vii., 13
capitata, vii., 13
Nycticorax nævius, x., 52
Nymphæaceæ, iii., 43, 45
Nymphæa pygmæa ix., 7
tetragona, ix., 7

Oakesia puberula, ix., 13
sessilifolia nitida (new), ix., 13
Oak-leaves of Alaska, large, iii., 95
Oaxaca, Mex., notes on a trip in, xiii., 204
Obelisk, New York, xii., 188
preservation by paraffine, v., 56, 63–71
Oberstein, Germany, lapidary work at, iii., 62
Obituary notice of Prof. Felipe Poey, x., 56
of Dr. J. I. Northrop, x., 120
Obolella nitida, xiv., 125
Obolus pristinus, xiv., 121
pulcher, xiv., 115
Observatories (astronomical), v., 260, 261
time service for, v., 158–162
Observations for variations of latitude made at Columbia College and the Royal Observatory at Naples, xiv., 7
on comet of 1892, xi., 120
on Gould's comet, ii., 18–23
of transit of Venus, ii., 51, 52
of Greenwich and Kew, xii., 27
time-signals from, i., 86, 87
of Columbia College, transit factors for, xi., 41
Obsidian, ii., 36; vi., 122: viii., 30, 162
arrow heads in Oregon, iii., 82
in volcanic ash, iii., 64
implements from Guatemala, i., 105
in rhyolite, v., 214
Occurrence of a large marine vertebrate, etc., v., 165–168
Ocean holes, x., 11
river and desert sands, iv., 3.
Ochre, v., 217

Octocoris alpestris, ix., 129, 131
adusta (new), ix., 131
avenicola, ix., 131
chrysolæma, ix., 131
Giraudi, ix., 131
leucolæma, ix., 131
Merrilli (new), ix., 131
pallida, ix., 131
praticola, ix., 131
rubea, ix., 131
strigata. ix., 131
Oculus beli, viii., 159
mundi, viii., 159
Œnantholaniline, ii., 62
Œnantholnaphthylamine, ii., 62
Œnantholxylidine, ii., 62
Œnothera, viii., 77
cæspitosa, i., 8
Hartwegii, vii., 9
rosea, vii., 9
speciosa, vii., 9; ix., 184
Office of parenchyma of leaf, iii., 39, 40, 44–46
Officers, election of, iii., 70, 71; vi., 110; viii., 129; ix., 109; xiv., 72
of Corresponding Secretary, v., 162
Recording Secretary, v., 29, 162
Librarian, v., 1, 20, 164
Treasurer, v., 163
reports of (see contents) vi.; viii., for 1894–95, xiii., 155
of Geological Section, re-elected, xiii., 203
nomination of, x., 57
Ohio, coal beds, ii., 87
sandstone, durability of, ii., 125, 126, 136
Oil fields of Colorado, viii., 25–28
Oils, see Petroleum, viii.,
of California, viii., 25
of Canada, viii., 25
of Colorado, viii., 25–28
of India, viii., 28
of Italy, viii., 25
of Ohio, viii., 25, 28
of Pennsylvania, viii., 25
of the Caspian, viii., 28
Oil testing, commercial, xi., 126
Ojrat Ramadân, ix., 23
Oleaceæ, vii., 11
Olenellus, not in Protolenus Fauna, xiv., 150
Oligoclase, vi., 77; viii., 2
from New York Island, v., 75, 223

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Oliva litterati, ix., 88
Olivine, ix., 190, 191, 193
meteoric, Kiowa Co., ix., 191
meteoric, Turner mound, ix., 193
meteorite containing, iv., 5
in metorite, vi., 73, 74, 76, 162
in metorites, viii., 161, 186
Olenellus Zone, place of, viii., 176
Ommastrophes, i., 175
Onagrarieæ, vii., 9
Oncorhynchus nerka, i., 6
Oneida conglomerate, v., 216
Onoclea sensibilis, ix., 31
Onosmodium Carolinianum, ix., 185
On photographs of Geisler and Crookes radiant matter tubes, xv., 156
Ontonagon, Mich., glacial phenomena at, iii., 14
Onyx, iii., 62
Oölites, v., 62
Opal, viii., 17, 30, 159, 161
mines, Hungary, xi., 32
Opals, ix., 150
Opercula, ix., 34
Ophileta complanata, xv., 21
Ophiolite, viii., 3, 53
Optic Nerve, in Brain of Skate, xv., 148
Opuntia, ii., 92
Oracanthus abbreviatus., ix., 132
fragilis, ix., 132
grandis, ix., 131
granulatus, ix., 132
Milleri, ix., 131
multiseriatus, ix., 132
vetustus, ix., 132
Orange, N. J., columnar trap, iv., 4
Orange County, N. J., geology of, xv., 70
Orbicular granite from Rhode Island, xiii., 140
Orbits of comets, ii., 22, 23
Orbulina, cf., *universa*, *ovalis*, *ingens*, *intermedius*, xiv., 109
Order of Court, x., supplement 3
Ordovician faunas at Larrabee Point, Vt., xv., 20
at Shoreham, xv., 20
rocks, xv., 19
Oregon, fire opal from, viii., 159, 161
Indian arrow heads of obsidian, iii., 63, 82
snow peaks of, iii., 77
volcanic ash, i., 55
Ore deposits at Franklin Furnace, N. J., xiii., 76
Ores and minerals of Sussex Co., N. J., ii., 25
of North Carolina, ii., 149, 150
Ores, Lake Superior, iii., 1, 2
silver, processes for amalgamation, iii., 1, 2
New Jersey Triassic, iii., 18, 19
in San Juan Mts., v., 122, 128
Organ-pipe sonometer, i., 163
Organic aromatic bases, compounds of, i., 100
compounds, new, ii., 62, 63
matter in water, determination of, ii., 111–114
structure in graphite, ii., 148
chemistry, discoveries in, v., 193–198
progress in, v., 193–198
matter in water, viii., 117
Origin of alphabet, v., 81–88
and distribution of Amphibian Cranial Nerves, xiii., 176
and history of mineralogical names, xi., 49
of mountains, xi., 45
of garnets, xi., 32
of carbon minerals, i., 109–111
of carbon in shales, ii., 110, 111
of graphite, ii., 148, 149
of iron ores, ii., 6–8, 13–17
of leaf forms, iii., 38–44
of Puget Sound, iii., 104
of sounds in nature, iii., 75
of petroleum, viii., 26, 27
of rock strata, v., 78, 79
of the heavenly bodies, xiii., 170
Ornamental stones of N. A., viii., 160
from Rome, ix., 95
Ornaments, paleolithic, viii., 133
Orobanchaceæ, vii., 12
Orohippus, vii., 158, 159, 160
Orsat apparatus, ii., 101
Orthid, xiv., 128
Orthis testudinaria, vii., 4
Orthoceras pelops, i., 57
Oscillariæ, vi., 49
Orthoclase, ii., 25, 147; iii., 49; iv., 42; viii., 12, 58
in sandstone, ii., 119, 120
from Weehawken, N. J., iv., 76
in Granite Diorite, xiv., 83

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Orthotheca cf *Emonsii*, xiv., 129
Osborn, Prof. Henry F., elected resident member, xi., 40
elected fellow, xii., 39
elected Vice-President, xii., 128
Ostrea, ii., 26, 94.
borealis, ii., 141; iv., 59
larva, ii., 10
Ostracoda of Protolenus fauna, xiv., 132
Otozamites, vii., 115
brevifolius, v., 18; vi., 126
latior, v., 18; vi., 126
Ottrelite, iv., 76
Outliers, x., 10
Oxalic acid produced by fungi, v., 114, 118
Oxalis corniculata, vii., 8
dichondræfolia, vii., 8
Drummondii, vii., 8
decaphylla, viii., 79
Oxidation of galena, v., 130
of pyrite, ii., 139
Oxygen, v., 185–188, 214
boiling point of, v., 191
in the sun, v., 243
liquefaction of, v., 190, 191
manufacture of, v., 192
in water, vi., 48–52
Oxyhydrogen light, x., 104
Oxytænia acerosa, viii., 77
Oxytropus Lamberti, viii., 79
Ozokerite, viii., 26
deposits, ii., 43-50
Ozone, v., 185
by oxidation, v., 119
literature of, iii., 34

Pacific coast of America, fishes of the, xi., 125
salmon, habits of young, xv., 148
Page Valley, Va., v., 216 217
Painting, mural, in Yucatan, v., 175
Paint, use on building stone, ii., 78
Paired fins, origin of, xii., 121
Palace builders, iv., 51
Palæobotany, Cretaceous, of Staten Island, xii., 28
Palæolithic arrow-heads, iii., 81, 82
stone implements, iii., 1, 7, 12, 81, 82
ornaments, viii., 133
skeletons, viii., 132–135
Palæoniscus, v., 18
Palæontology of Cretaceous formation of Staten Island, xi., 96
Palæospondylus, Marsipobranchian characters of, positive and negative, xv., 103
Palæozamia auctifolium, vii., 115
Cutchensis, vii., 115
Palæozoic Crustacea, viii., 152
rocks, in America, v., 78, 79
strata, 216
Paledaphus, ii., 146
Palisades, v., 230
Palissya diffusa, vi., 126
Paliurus affinis, xii., 35
Pallasite, Kiowa Co. diagrams, ix., 192
Turner Mound diagrams, ix., 192
Palmettos, x., 6
Palm fossil, at Florissant, iii., 77
near Green River, iii., 13
Palms, from Vancouver's Island, v., 133
Panama Canal, viii., 165, 168, 169, 170
humidity of, viii., 85, 86
termites at, viii., 85–114
Pancreas Cell, Morphology of, xiii., 176
Pandanus, iii., 47
Panicum autumnale, ix., 182
capillare acuminatum, ix., 182
dichotomum pauciflorum, ix., 14
viride,, ix., 14
lacnanthum, ix., 182
nitidum pauciflorum (new), ix., 14
viride (new), ix., 14
subspicatum, ix., 182
Texanum, ix., 182
leucophænum, vii., 14
Panus stypticus, v., 111
Papaveraceæ, vii., 7
Paper wheels, railway, v., 152
Pappophorum apertum, ix., 182
Paradoxides Beds, Faunas of, in Eastern N. A., xv., 192
Description of Genera and Species, xv., 194
Lepiditta xv., 194
alatæ, xv., 194
Curta, xv., 195
auriculata, xv., 196
Ostracoda, xv., 196
primitia, xv., 196

Digitized by Google

Paradoxides Beds, Faunas of, in Eastern North America.
Primitia Acadica, xv., 196
Aluta, xv., 198
flexilis, xv., 198
cirrepedia, xv., 198
Plumulites Barrandi, xv., 199
Manuelensis, xv., 200
Stenotheca salter, xv., 200
concentrica, xv., 201
triangularis, xv., 203
nasuta, xv., 204
Hicksiana, xv., 205
radiata, xv., 202
Cirripodites, n. gen., xv., 205
Cambrensis, xv., 206
Explanation of plates, xv., 206
Sculpture, xv., 207
Trilobita, xv., 207
Agnostus, xv., 207
regulus, xv., 213
fallax, xv., 214
parvifrons, xv., 212; 220
obtusilobus, xv., 212
Davidis, xv., 213
rex, xv., 214
similis, xv., 215
vir, xv., 215
concinnus, xv., 216
longifrontes, xv., 210
limbati, xv., 211
parvifrontes, xv., 212
lævigati, xv., 212, 233
trilobatus, xv., 216
Acadicus, xv., 217
declivis, xv., 219
Tessella, xv., 221
truncatus, xv., 222
umbo, xv., 222
obtusilobus, xv., 223
Davidis, xv., 225
gibbus, xv., 226
marlitus, xv., 227
acutilobus, xv., 227
Nathorsti, xv., 229
confluens, xv., 230
fissus, xv., 230
trifissus, xv., 231
punctuosus, xv., 232
terranovicus, xv., 233
Ciceroides, xv., 234
Mamilla, xv., 234
nudus, xv., 235
Microdiscus, xv., 235
Scheme of relation, xv., 237
Microdiscus Schucherti, xv., 238
Precursor, xv., 239
Dawsoni, xv., 240
pulchellus, xv., 242
punctatus, xv., 244
Explanation of plates, xv., 245
Trap dikes in the Adirondacks, Pre-Cambrian and Post-Ordovician, Introduction, xv., 248
Present rock classification, xv., 248
proposed change in classification, xv., 249
the dykes, xv., 249
distribution, xv., 250
scarcity north of Adirondacks, xv., 251
summary, xv., 252
Paradoxides Zone, place of, viii, 176
Paraffine, v., 194
application in building materials, v., 56, 71
group, v., 196
from ozokerite, ii., 48, 49
Paraguayan plants, xi., 131
Paraguay, the land and the people, xi., 24
Parallaxes, note on determination of xiii., 75
of stars, v., 259
of stars in Cassiopeiæ, xii., 56
Parenchyma of leaf, office of, iii., 39, 40, 44, 46
Parexus, xii., 125
Pargasite, ii., 149
Parietaria debilis, vii., 4; viii., 81
Paris, Exhibition of 1889, Minerals of, ix., 145
lecture on, ix., 200
Exposition, viii., 152, 160
Park, Adirondack, x., 111
Parker, Herschell C., elected resident member, xiv., 220
Parkinsonia aculeata, ix., 184
Paronychia Jamesii, ix., 185
Parthenium hysterophorus, vii., 11
Paspalum pubiflorum, ix., 182
Passifloreæ. vii., 9
Passiflora tenuiloba, vii., 9
Patagonia, expedition to, xiii., 207
Patents for driven wells, vi., 91
Patriofelis, xiii., 131

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Patrons, of the Academy, list, iii., 113; viii., 207; x., supplement; xv., end of
Paulownia imperialis, ix., 12
tomentosa, (new), ix., 12
Pavements of cities, viii., 41, 44
Pearl from Shrewsbury River oyster, iv., 59
Pearls, American, viii., 162, 163
green, viii., 162
pink, viii., 162
Peary, Lieut., Relief Expedition for, xiv., 100
Peat, Transformation of, i., 71, 76
artificial conversion into coal, i., 75
Pecopteris bullatus, vii., 115
Pecten, ii., 11
Madisonius, ix., 88
Pectis, viii., 77
Pectolite, ii., 88; viii., 162; ix., 141; hammer, vi., 111
Pectoralis, anomalies of, xii., 138
Pedicularis Parryi, viii., 78
Pegmatite, v., 222; viii., 54, 55
Pelagiella atlantoides, xiv., 131
Pell, Alfred, elected resident member, xv., 147
Pelypteris Texana, vii., 11
Peneplains, Cretaceous and Tertiary of Eastern Tennessee, xv., 143
Penicillium glaucum, vi., 69
Pentremites Sampsoni, vii., 247
Penstemon, viii., 77
Bridgesii, viii., 79
glaucus var. *stenophyllus*, viii., 78
unarioides, viii., 79
Palmeri, viii., 80
Peperino in Texas, i., 52
Perezia nana, ix , 184
runcinata, vii., 11
Peridium, ix., 33
Peridote, viii., 53–161
Peridotite, intrusion, xiv., 86
Periodic, errors of graduated circles, xiii., 205
"Periodic law," in Chemistry, v., 183, 184
Peristerite, viii., 162
Perissonychia, xii., 96
Peritricha planicola, ix., 34
Perofskite, iii., 17
Peronosporites, xiii., 131
Peroxide of Copper, v., 215, of Potassium and Sodium, v., 214, 215
of hydrogen, literature of, iii., 34
Perpetuation of names of men of science, by municipal government of Paris, in nomenclature of streets, xiv., 46
Perpetual motion, apparatus for, xii., 2
Perspective, binocular, i., 9–15
Peru, silver castings from, iii., 15, 62, 63
Pescadero, x., 31
Petalostemon gracilis, vii., 9
Peterophyllum Blasii, vii., 115
Braunsii, vii., 115
princeps, vii., 115
Petrified, forest in Colorado, iii., 6, 7
wood from California, viii., 29, 30
from New Mexico, viii., 77
Petrographical notes, xi., 126
notes on Rocks, from Alaska (by title), xiv., 185
notes on Rocks from Alaska, xv., 23
Petrography of gneisses, xii., 203
Petroleum, ii., 43; v., 193–196
of Colorado, viii., 25–28
age of, viii., 25, 26
character of, viii., 26
origin of, viii., 26, 27
in quartz, x., 57
testers, i., 139–143
Petromyzontidæ, v., 89.
Pettigrew, Dr. David Lyman, elected resident member, xv., 272
Peziza aeruginosa, x., 37
jungermanniæ, x., 37
Pfister, J. C., elected resident member, xiv., 48
Phacelia circinata, i., 8
congesta, ix., 181
Phacolite, viii., 54
Phacus, ix., 33
Phalangidæ of the United States, xi., 125
Phanerogams, new and noteworthy, ix., 6
Phaseolus diversifolius, ix., 10
helvolus, ix., 10
umbellatus (new), ix., 10
Phenacite, viii., 12
Phenomena of chemistry, v., 199

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Philadelphia, geologists in, xi., 45
rocks of, viii., 47–53
Philadelphite, viii., 50
Philibertia undulata, ix., 184
viridiflora, vii., 11
cyanchoides, vii., 11
Philippium, v., 200
Phillipsia insignis, vii., 249
Sampsoni, vii., 247, 249
trinucleata, vii., 249
tuberculata, vii., 247, 249
Philippian Pulmonate, Varietal tree of, xv., 137
Cochlostyla ovoidea, xv., 137
types of bands, xv., 139
Correlation between size and color, xv., 139
Species from Varieties, xv., 140
Transmission of acquired characters, problem of, xv., 141
Evolution in fossil Cephalopods, xv., 141
Phlogophite, iii., 49
Phlox Drummondii, ix., 185
Roemeriana, ix., 185
speciosa, var. *Woodhousei*, viii., 80
Phococyan, vi., 49
Phœnicopterus ruber, x., 52
Phœnix, Lloyd, elected resident member, xiv., 154
Pholas, vi., 31
Phosphate beds of Florida, ix., 85
Nodules from the Cambrian, xii., 108
Phosphorescent diamonds, xiv., 260
wood, x., 37
infusorian, v., 15, 16
Phosphorescence of fluorite, iii., 77, 100
of marine animals, v., 14, 16
Phosphoric acid, exhaustion in soil, iii., 16
Phosphorus, v., 186, 187
in meteorite, vi., 92
Photographic measures, Rutherfurd, xi., 41
Photography, v., 248
applied to astronomy, i., 143, 146
recent advances in, i., 176
of Manometric flames, xiii., 205
Photographs of caves, ii., 41
of scientific men, iv., 5
of stars, v., 257
of sun, v., 241, 246
Photo-micrographs, xiv., 71
processes and results, iii., 105
of wood sections, iii., 107
Photosphere of sun, v., 242
Photometric differences, method for determining, v., 155
Photometry, solar, viii., 156
stellar, x., 117
Photo-micrography, suggestions in, ix., 76
Phyllanthus polygonoides, vii., 13
Phyllite, iv., 75
Phyllites poinsettiodes, xii., 37
Phyllocladus, iii., 47
Physa, v., 218
Physalis Fendleri, vii., 12
Physeter macrocephalus, xii., 50
Physical conditions in formation of coal, ii., 50
theories, moral bearing, i., 96–99
Physics, relation with chemistry, v., 189, 190
Physiology, application of chemistry to, v., 198
scope of modern, xiii., 98
Physiological chemistry, v., 198
Physonemus Altonensis, ix., 133
Phytolacca, iii., 88
Phytolaccaceæ, vii., 13
Pickling of ancient silver castings, iii., 15
Piercing of granite by use of corundum, iii., 105
Pierson Israel C., elected Fellow, xv., 134
Piffard, Henry G., elected resident member, xv., 147
Piffard, salt well, ix., 41
Pinaropappus roseus, vii., 11
Pinus, v., 136; xii., 31
aristata, viii., 77
edulis, ii., 91; viii., 76
ponderosa, i., 8; viii., 76, 78
succinifer, viii., 157
bahamensis, x., 6
flexilis, i., 5
inops, v., 222
mitis, v., 111
palustris, v., 111, 112
Piperidine, v., 195, 197
Pitch lake of Trinidad, viii., 26
Pittsburgh, Penn., acidity of atmosphere, iii., 65, 66
Pittsford, Vt., marble, viii., 101, 102

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Pituiary body, the, xii., 27
Placer mining, viii., 149
Placoderm fishes in Devonian of Ohio, v., 25
Placoderms of the Devonian, iii., 54
Plagioclase in granite diorite, xiv., 82
Planariæ, v., 48
Planaria, ix., 33
Planet Mars, drawings made of the markings on, xv., 64
Planets, v., 247-253
  inferior, v., 247
  intra-Mercurial, v., 247
  major, v., 251
  Mercury, v., 248
  Venus, v., 248
  Mars, v., 249-250
  Asteroids, v., 250
  Jupiter, v., 251
  Uranus, v., 252, 253
  Neptune, v., 253
  Saturn, v., 251
  ultra-Neptunian, v., 253
Planorbis levis, viii., 114
Plantagineæ, vii., 13
Plantago Patagonica, vii., 13
  Virginica, vii., 13
Plants, annual growth-rings in, iii., 88
  fossil in Colorado, iii., 13, 77
  of Northern Tertiary, present range, iii., 96
  Cretaceous, v., 133-137; vi., 16
  Triassic, vi., 125, 126
  distribution, xii., 189
  evolution, xiv., 49
  fossil, from Providence, R. I., iv., 76
  from Worcester, Mass., iv., 75
  from Staten Island, v., 28, 29
  in siliceous soil, v., 217
  of Arizona, viii., 61-81
Planting of Trees, iii., 35
Plastic clays, new fossils from, viii., 177, 178
Platanus, iii., 47; xii., 33
  Aquehongensis, xii., 32
  Newberriana, xiii., 181
Platinum, v., 185, 187
  Experiments upon, xiv., 174
Plattsburg, N. Y., singing beach at, iii., 73
Pleistocene Lake bed at Elizabethtown, N. Y., xiii., 107
Pleurosima, ix., 35
Pliohippus, vii., 159, 160
Plover, eggs of, xi., 24
Pnigeacanthus deltoides, ix., 132
Poa, viii., 79
Podozamites, v., 136
Pointing of building-stone, ii., 123
Polariscope xv., 135
Polarization of Light, Arago's explanation, xiv., 158
  Historical Review, xiv., 156
  Qualitative experiments, xiv., 160
Polar stars, catalogue of, xii., 186
Polemoniaceæ, vii., 12
Polemonium confertum, viii., 78
Poliopstila albiventris, v., 55
  cærulea cæsiogaster, x., 52
Polorthus, ii., 85
  tibialis, ii., 12
Polygala alba, ix., 183
  ambigua, ix., 9
  puberula, ix., 183
  verticillata, ix., 183
  verticillata ambigua, new, ix., 9
  ovalifolia, vii., 8
Polygaleæ, vii., 8
Polygonaceæ, vii., 13
Polygonum Bistorta, viii., 79
  emersum, ix., 185
Polynemidæ, ix., 15
Polyodon, xii., 122
Polyporus abietinus, v., 111
  applanatus, v., 111, 113
  destructor, v., 110
  gilvus, v., 111
  hybridus, v., 110, 111
  lucidus, v., 110
  nidulans, v., 111
  pergamenus, v., 111
  pinicola, v., 111, 114
  salicinus, v., 111
  sulfureus, v., 111
  versicolor, v., 111, 113
Ponds, artificial, viii., 117-125
Populites, xii., 33
Populus, v., 135; ix., 31; xiii., 133
  angustifolia, ii., 92
  monilifera, ii., 92
  apiculata, xii., 31
Porcupine Mountains, Mich., geological structure, iii., 14
Porifera, v., 55
Porliera angustifolia, ix., 181
Porphyrite, ix., 143

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Porphyrites, xiv., 203
Porphyritic gneiss, viii., 49
Porphyry, i., 19, 49; ii., 94; viii., 162
in Colorado, v., 122, 124, 126, 127
of St. John, xiv., 196
syenites, v., 220
Port Kent and Ausable Chasm, xv., 21
Portraits of Priestley, viii., 17–20
Portulaca parvula, vii., 8
Postage on natural history specimens, xiii., 122
Post, Dr. A. C., death of, v., 280
Post, George B., elected resident member, xiv., 154
Potassium, v., 187
chlorate of, v., 215
hydroxide of, v., 193
peroxide of, v., 214–215
Potash brine, analysis of, ix., 41
Potentilla rivalis, var. *millograna*, viii., 79
subviscosa, viii., 80
Thurberi, viii., 78
Pothocites Grantoni, iii., 40
Pot-hole, ix., 3
Pot-holes, x., 8
near Williamsbridge, N. Y., i., 181–183
"Potomac" clays, v., 136
group, geological age, etc., x., 36
Potsdam rocks of S. E. Penn., viii., 48, 50, 51
sandstone, figures on, iv., 42
strata, v., 216, 217
Poulton, Prof. Edward, elected corresponding member, xiii., 171
Powder-mill Creek meteorite, vi., 161, 162
Praseodymium, v., 184, 200
Pre-Cambrian and Post-Ordovician trap dikes in the Adirondacks, xv., 248
Introduction, xv., 248
Present Rock Classification, xv., 248
Proposed Change in the Classification, xv., 249
The Dikes, xv., 249
Description, xv., 249
Distribution, xv., 250
Scarcity north of the Adirondacks, xv., 251
Summary, xv., 252
Pre-Cambrian, classification of, xiv., 195
topography of the Adirondacks, xv., 189
upper limit of, xiv, 194
volcanic rocks, xiv, 189
Precious stones of North America, viii., 160
Precipitation, to purify water, vi., 52, 53
Preglacial drift, vi., 16–18; viii., 179
of New Jersey and Staten Island, iv., 26; glacial drift, iv., 30
Prehistoric man in America, v., 120
races of America, skill of, iii., 15
Prehnite, ii., 88; viii., 2; ix., 141
new locality, v., 80
Preliminary notes in meteorite, v., 231
Preservation of building materials, etc., v., 56–71
of building stone, v., 13
of organic tissue, v., 117
of wood, v., 116–120
of stone, artificial, ii., 77, 78
Prevention of tubercular disease, i., 181
Price of the Transactions, x., 1
Priestley, Dr. Jos., decease, ii., 111
likenesses of, viii., 17–20
"Lunar Society," associates of, viii., 23, 24
Primary Matter, v., 184
Prime, Mr. Rufus, vi., 41
Primitia aurora, oculata, fusiformis, xiv., 136, 137
Primitive education, xv., 155
Primula parryi, i., 8; viii., 78
Prince, J. Dyneley, xv., 147
Principal lines of disturbance in certain portions of Atlantic Coastal Plain, xiv., 9
Problems about to confront astronomers of the Twentieth Century, xv., 146
Proboscidia, iv., 19, 20
Proceedings, American Association for the Advancement of Science, ix., 25
Process for amalgamation of silver ores, iii., 1, 2
Process of cutting intaglios and cameos, iii., 105
Prochlorite, vi., 130

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Procyon lotor ileo-colic, junction of, xii., 50
Products of ozokerite, ii., 48, 49
Productus, v., 122
Prætus, vii., 247
Progress in astronomy, v., 234
of standard time, xi., 45
Projections, lantern, x., 103
Prominences, solar, v., 244, 245
Proserpinaca palustris, iii., 43
pectinacea, iii., 44
Prosopis glandulosa, ii, 92
juliflora, vii., 9; ix., 184
Protæoides daphnogenoides, xii., 36; xiii., 130
Protagraulos priscus, xiv, 139
Protection of building stone, ii., 76, 77
Protective influence of mitigated virus, v, 204–213
mimicry, viii., 117
Protobatis quadratus, xii., 39
Protochlorite, viii., 53, 54
Protococcus, viii., 68–115
pluvialis, viii., 68
viridis, viii., 68
Protohippus, vii., 159
Protolenus Fauna (by title), xiv., 100
more primitive and more pelagic than that of Olenellus, xiv., 102
possibly cotemporaneous with the Fauna of Olenellus, xiv., 102.
Protolenus paradoxoides bituberculatus, xiv., 145
Protopterus, xii., 244
Protospongia, xiv., 112
Protozoa, v., 54.
Protozoölites, new species, ix. 32
Prunus demissa, viii., 80
Psammite, viii., 43, 44
Pseudomorphs, viii., 45, 54, 60
after garnet, iii., 1
copper, ix, 140
Pseudotsuga Douglasii, viii., 78
Psilophyton princeps, vi, 5–9
Pterichthys, ii., 144
corrugatus, iii., 32
Pterophyllum Blasii, vii., 115
Braunsii, vii., 115
princeps, vii., 115
Ptychoceras, ii., 94
Pthalic acid, v., 195
Ptycholepis, v., 18
Marshii, vi., 127
Ptychoparidæ, not in the Protolenus Fauna, xiv., 150
Publication Committee, report, iii., 12, 70
fund, list of contributors, iii., 121
Committee, ix., 1, 107, 108
fund, money for, xiv., 92
Publications of Academy, list of recipients, iii., 138–149
of the Academy, viii., 1, 2, 41, 117, 127, 128, 152, 177
Public lectures, xv., 62, 123, 146
Puerco, relation to the Laramie, xii., 69
Puget Sound, origin of, iii., 104
Pulmonate molluscs, lingual dentition, iii, 71
Pumice, i., 49–52, 56
Pupa longurio, ii., 152
Purification of water, vi., 42–58
Pyræsolite, viii., 59
Pyramids of Egypt, ii., 114–116
Pyridines, v., 195
Pyrite, ii., 25, 90, 94; 138, 139, 149; iii., 21, 23; iv., 41; vi., 71–130; viii., 54, 56, 57, 60, 140; xii., 69
Pyrites, v., 121, 192, 230
Pyrogranil, ix., 149
Pyrope, viii., 161
Pyrotechnical photography, ix., 76–99
Pyroxene, viii., 58
Pyroxene, ii., 9–25; iii., 18; iv., 42
in iron ore, v., 221
Pyroxenes from New York State, xiii., 208
of New York State (by title) xiv., 100
Pyroxenite, vi., 130; viii., 53–55
hollow crystals, vi., 112, 122–124
hydrophane, vi., 111, 112
Pyrrhopappus Carolinianus, ix., 184
multicaulis, vii., 11; ix., 181
Pyrrhotite, ii., 25–147; vii., 254
Pyrrol, v., 195

Quaker Bridge dam, viii., 117–125
Quartz, ii., 100–118; iii., 12, 18, 23, 49, 72
after calcite, v., 133
coated with chlorite, v., 214
cutting of, etc., v., 266, 267–277
from Arizona, v., 133
from Arkansas, v., 265

Digitized by Google

Quartz, green, v., 229, 230
in cavities of rhyolite, v., 214
in Luray caverns, v., 217
milky laminated, v., 97
pseudomorphs of, v., 266
crystals, fluid-bearing, i., 131–136
crystals from Ellenville, N. Y, xiii., 181
gems, viii., 161
inclusions, viii., 21–161
"phantom," viii., 12
smoky, vi., 113-130; viii., 161
in lithomarge, vi., 3
in meteorite, vi., 35
in granite diorite, xiv., 81
petroleum in, x., 57
Quartzite, v., 222; viii., 53, 54; x., 59
at Balcony Falls, v., 219, 220
in E. Tenn., v., 220
in Page Valley, v., 217
in San Juan Mts., v., 122–125
in Essex Co., N. Y., xiii., 219
Quarternary fauna of Belgium, viii., 132–134
in Essex Co., N. Y., xiii., 226
of Staten Island, viii., 177, 180, 181
Queen termites, viii., 87, 89, 106–110
Quercus, xiii., 17
coccinea, var. *tinctoria*, iii., 42
nigra, iii., 42; v., 217
Emoryi, ii., 91
grisea, viii., 76
hypoleuca, viii., 76
oblongifolia, viii., 76
undulata, var. *Gambelii*, viii., 76
imbricaria, iv., 31
obtusiloba, v., 217
Quinine, v., 195
Quonochontogue Beach, R. I., orbicular granite, xiii., 140

"Rackarock," v., 14
Radiant matter, v., 178
Radiata, v, 32, 33
Radiolaria, ix., 33
Rails of railroads, v., 145–148, 152
Railway problem in China, xi., 44, 156
Railways, appliances of, v., 149
extent of, v., 149, 150
inception and progress of, v., 137–152
income of, v., 151
rates of, v., 150
signals of, v., 149
Rainfall, vi., 79, 80
annual, ix., 209
in Denver, Colorado, ix., 209
on the Nile, ix., 113
of Panama, viii., 85, 86
Raiyan Mœris, ix., 55
Rallus coryi, x., 52
Rana clamata, xii., 243
Randite, viii., 50
Ranunculaceæ, vii., 7
Ranunculus cardiophyllus, viii., 79
Hookeri, viii., 79
aquatilis, iii., 43, 46
multifidus, iii., 43
repens and its allies, xii., 2
from Virginia, xiv., 79
Rapid City, Dak., aragonite, iii., 17
Rare gems, etc., v., 131–133
"Raritan" clays of N. J., v., 136
Ravages of termites, viii., 86, 90, 93, 99, 100, 110
Ravenia Blandi, ii., 154
Rays, fossil, from Wyoming, iii., 38
Recent progress in chemistry, v., 179-202
Reception by the Council, viii., 20
and exhibition by the Academy, xiii., 159
Recording Secretary, report of, iii., 68; ix., 104; xiv., 87
resignation of, viii., 1, 4, 7
Redfield, Mr. J. H., memorial committee, xiv., 100
Red sunsets, brilliant colors of, iii., 32, 61
theories in regard to causes, iii., 60, 61, 64, 65
Redondo Beach, musical sand at, x., 31
Reduction of astronomical photographs, xiii., 121
of astro-photographic plates (by title), best formulæ for, xv., 2
of transit observations by least squares, xi., 25
Rees, J. K., elected Councillor, xii., 128
Refreshment of muscles, vi., 118, 121
Regeneration, xii., 139
Relacam, vi., 61

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Relation of certain thermodynamical phenomena of liquid solutions to the economy of nature, ix., 138
Relations of Arthrodiran fishes, xiii., 176
of dinichthys, iii., 20
Remains of fossil fishes, ii., 144–147
Remarkable nugget of silver, xv., 191
Remoplenoides Schlotheimi, vii., 9
Report, of Committees, iii., 56–60, 70
Committee on Forestry, x., 115
Conference Committee on union of local scientific societies, x., 112
Corresponding Secretary, ii., 95; iii., 68; v., 162
Librarian, ii., 98; iii., 70; v., 1, 20, 164, 282
Library Committee, i., 125
Publication Committee, i., 125; ii., 98, 99, 154; iii., 70; v., 1, 164
Recording Secretary, i., 125; ii., 97, 98; iii., 68; xi., 93; xii., 127; v., 29, 162, 278
Treasurer, i., 124; ii., 96, 97; iii., 69; xii., 126; v., 163
Reports of Committees, xiii., 23, 151
Memorial Committee, v., 278
officers, v.; vi. (see Contents); viii. (see Contents); xiii., 152; xv., 128
Reproductions of rock sections, in polarized light, photographed, xiv., 64
Reptilian foot-prints in New Jersey Trias, v., 72
Researches in the solar spectrum, xi., 125
Reservoirs, viii., 117 124
Resident Fellows and Members, list, iii, 114–122; x., supplement
members, election of, iii., 31, 55, 71, 80, 100, 106
members, list of, viii., 209; xv., end of vol.
Resignations, vi., 112
of members, iii., 34, 37, 48, 55, 62, 72, 103
Resins, fossils, ii., 85–87
Resolution regarding metric system of weights and measures, xv., 125, 127
Resolutions on death of Dr. John C. Jay, xi., 40
passed, ii., 24, 62, 79, 100, 111, 116, 154; iii., 56–60, 71, 106
Results of experiments on metallic spheres falling in water, preliminary series, xv., 2
Reticulate structure of living matter, ii., 79–84
Reversion spectra, v., 182
Review of Diodontidæ, etc., v., 89
of dynamic electricity, v., 89–110
of fossil fishes, etc., 233
of Petromyzonitidæ, v., 89
Revised by-laws, x., 49
Revision of by-laws, committee on, x., 37
of Calceocrinidæ, viii., 152
of Cambrian rocks, viii., 176
Rhacicallis rupestris, x., 15
Rhamnaceæ, vii., 9
Rhamnus Rossmassleri, xii., 35
Rhigolene, v., 194
Rhinoceros Merckii, viii., 135
tichorhinus, viii., 133
Rhisobia, Occurrence and Functions of, xiv., 79
Rhizodus, vi., 138; vii., 165
anceps, vii., 165
Hardingi, vii., 165
Hibberti, vii., 165
lancifer, vii., 165
occidentalis, vii., 165
quadratus, vii., 165
Rhizomorphs, x. 16
Rhizopoda, ix., 36
Rhodochrosite, ii., 64; vi., 112
from Ulay mines, Colorado, i., 3
Rhododendron nudiflorum, ix., 184
Rhodonite, ii., 28–35; viii., 162
from Franklin, N. J., v., 25
Rhopolocera, xiv., 60
Rhus aromatica, ix., 183
Canadensis, ix., 183
radicans, ix., 183
toxicodendron, ix., 183
Rhynchophora, vii., 162
Rhynchosia Texana, vii., 9
Rhyolite, i., 53, 173
at Yellowstone Park, iii., 7
holding topaz, v., 213
Ribes aureum, viii., 76
cereum, viii., 80
lacustre, (?) viii., 78
Richmend, Mass., deweylite from iron mine, iii., 17
Ries, Heinrich, elected resident member, xi., 25

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Ring structure of carbon compounds, v., 165
Rio Grande, botany and geology near, ii., 66, 90–95
Ripidolite from Jerome avenue, N. Y., iv., 78
in New York City, iii., 48
Rise and progress of invertebrate zoology, v., 29–55
River mussels, viii., 163
Rivina lævis, vii., 13
Robb, Prof. W. L., vibration of a cord, xv., 135
Rock, crystal, boulder of, iii., 81
exposures on New York Island, x., 113
crystals, etc., v., 267, 277
salt deposits, ix., 39
salt from Leroy and Livonia mine, N. Y., xii., 6
sources of, xii., 269, 276, 277
thin sections, i., 49-53, 154
salt in Western New York, some discoveries, iv., 55
Rocks, Æolian, x., 7
effusive and Dyke near St. John, N. B., (by title) xiv., 100
of S. E. Pennsylvania, viii., 47–53
Rocking stone at West Farms, xi., 13
Rocky Mountain Parks, scenery of, iii., 108
Rogenium, v., 200
Rome, variety of marbles in, iii., 102
Röntgen Rays, new results of experiments, xv., 47
Röntgen's discovery, xv., 146
Rose-quartz, viii., 161
Rotation of earth, v., 236
Rotifer, ix., 33
Rotlbœllia corrugata, ix., 182
Royal Bohèmian Soc. Sci., viii., 114
Society, Committee to aid in work of, xiv., 99
of London, viii., 82
Rubiaceæ, vii., 10
Ruby, vi., 4–11, 12
artificial, vi., 4–11, 12
enclosing spinel, iii., 21
from North Carolina, v., 72
from Franklin, N. C., v., 132
Rudeville, N. J., Tourmaline Crystals from, xiii., 185
Reullia humilis, ix., 185
ciliosa humilis, (new), ix., 185
tuberosa, vii., 12
Rumex, viii., 77
Arizonicus, viii., 73
Berlandieri, vii., 13
Rusophycus, iv., 78
Russell, Mass., garnet pseudomorphs, iii., 18
Russel, Prof. I. C., viii., 180, 181
Rutaceæ, vii., 8
Rutgers Female College, viii., 20, 21
Rutherfurd, L. M., life of, xii., 27
death of, xi., 155
Star plates, reduction, x., 102
photographic measures, xi., 41
photographs, permanence of, xv., 147
Rutilated quartz, viii., 21, 161
Rutile, iii., 38, 49, 107 ; v., 75, 76, 264 ; vi., 3, 6, 130
enclosed in emerald, ii., 3
in garnet, v., 225–226, 227
penetrating a Ceylonese Zircon, iv., 59

Saba, W. I., geology, i., 23
Sabine, Wm. T., elected member, xv., 147
Saccharomycetus, vi., 68, 69, 70
Mycoderma, vi., 68, 69
Sacramento Valley, Cal., Indian mythology, iii., 55
Safety of kerosene oil, i., 137–143
Saguenay Valley, ii., 1–2
Sahara, microscopic examination of sand, iii., 64
Saibling, Sunapee, xii., 139
Salem witchcraft excitement, i., 150–153
Salicine, i., 197
Salina group, rock salt deposits of, ix., 39
Salisburia, iii., 44–47
Salix, v., 136; xii., 36
nigra, ix., 185
rostrata, viii., 79
Salizaria, ii., 92
Salmo fontinalis, xii., 140
Salmon fishery in Salmon river, i., 6
Salpa, v., 15, 16
Salt Cay, x., 5
Salt mines, ix., 45
production, ix., 44
of copper, v., 215

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Saltpetre, v., 214, 215
Saltville, W. Va., gypsum and salt, iv., 1
Salvelinus, xii., 139
Salvia ballotæflora, vii., 13
Texana, viii., 13; ix., 185
Samarium, v., 181–200
Sambucus glaucus, viii., 80
Sam's Point, N. Y., elevated terraces at, iii., 27
glaciation at, iii., 26
Samuel, Mark, elected resident member, xiii., 23
San Carlos mine, ii., 94, 95
Sand, microscopic examination of, iii., 64–75
of Sahara, iii., 64
sonorous, iii., 72–76
musical, x., 28
storms, ix., 115
Sands, iron, concentration of, ii., 7, 8, 14–17
Sahara, ii., 148
sonorous, ii., 148
ocean, river and desert, iv., 3
Sandstone, ii., 68, 72, 117–120, 122–127
in northern Texas, i., 15–19
Sandstones at Balcony Falls, v., 219, 220
decay in, v., 13, 59, 61, 62
in San Juan Mts., v., 122–126
Chemung, with screw-like casts, iii., 33, 34
head from Staten Island, iii., 81
leaf bearing, iii, 30, 31
used for building in New York City, iv., 57
San Francisco, forest, viii., 78, 79, 80
Mts., viii., 76, 77, 78, 79, 80
flora of, viii., 61–81
musical sand at, x., 32
San Juan, exploring expedition, v., 130
Mts. of Col., v., 121–130
Sanitary chemistry, v., 198
influence of vegetation in cities, v., 264
Sankaty Head, Post Pliocene, xv., 10
Deposits, Mollusca, xv., 12
Santa Barbara, musical sand at, x., 31
Saturnina (*bombycina*), xiv., 54
Saurians, gigantic, ix., 25
Saurothera bahamensis, x., 52
Sapindus marginatus, ix., 183
Morrisoni, xii., 235
Sapium (?) *annuum*, vii., 14
Sapphire, iii., 53, 107
artificial, vi., 8
from Ceylon, i., 129
yellow, xi., 58
Sap-sand in maple juice, i., 168
Sarcostemma cynanchoides vii., 11
Sargasso Sea of Atlantic Ocean, iv., 58
Sargassum bacciferum, iv., 58
Sassafras, iii., 41, 47, 94, 96 ; v., 136
acutilobum, xii., 236
Satellite, of Jupitur, xii., 27
Satellites of Mercury, v., 247
of Venus, v., 249
of Mars, v., 240, 253
of Jupiter, v., 252, 253
of Uranus, v., 252, 253
of Saturn, v., 252, 253
of Neptune, v., 253
Satin-spar, viii., 2
Saturn, v., 252
crape ring of, xii., 218
Saturnia (*sarnia*) *Cecropia*, ii., 117
Scandium, v., 181, 183, 200
Scapolite, v., 75 ; viii., 162
Scenery of Iceland, viii., 184
of the Rocky Mountain Parks, iii., 108
Staten Island, v., 228
Schaefferia cuneifolia, vii., 8
Schorlomite from Maine, iv., 25
Schermerhorn, Wm. C., elected resident member, xi., 25
Schistose rocks in Adirondacks, v., 72
Schists of S. E. Penna, viii., 49, 50.
Schizoneura laticostata, v., 17
planicostata, vi., 126
Schkuhria Hopkirkii, viii., 78
Schmidtella cambrica, xiv., 137
Schoenus nigricans (new), ix., 14
Schorlomite, viii., 162
School children, results of measurement, xv., 155
Schrankia angustata, vii., 9
Schreibersite, vi., 76, 145
Science of mechanics, historical sketch of development, xiv., 64
Scientific Alliance, xiv., 78
of New York, xii., 1, 137, 151
foresting, viii., 32

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Scientific influence of grange associations, iii., 16
jottings on the Nile, ix., 110
libraries of Europe, viii., 3
Scirpus and *Rhynchospora*, species of, xi., 74
atrovirens pallidus, (new), ix., 14
Sciurus aurocapillus, x., 52
Scleria, A Revision of the North American species of, iv., 80
Scolithus, iv., 30; viii., 51
linearis, v., 219
Scotland, lochs and crannogs of, xi., 48
singing beaches, iii., 73
Scranton, Penn., Peat, i., 71–76
Screw-like casts in Chemung sandstones, iii., 33–34
Scrophularineæ, vii., 12
Scutellaria Drummondii, vii., 13
Scyonotus, monograph of, xiii., 169
Sea-coast defence, vi., 122
Sea garden, x., 5
level, vi., 39
Salt, influence in decay of stone, ii., 123
sickness, treatment by trance, ii., 64–66
serpent, v., 165–168
Seal of Academy, v., 232
Seals, Babylonian, Assyrian, Sassanian, minerals used in, xiv., 87
Seasoning of building-stone, ii., 76-77
Sea urchin fertilization, xiv., 71
Seaweed from Trenton rocks, of Wisconsin, xix., 63
Secretary's report, xv., 128
average attendance, xv., 129
papers classified, xv., 129
elections, etc., xv., 129
new section formed, xv., 129
public reception, xv., 129
publications, xv., 130
Section of Astronomy, x., 67; xii., 26, 47, 93
Ethnology, x., 100
of Astronomy and Physics, xii., 55, 138, 186
Biology, xii., 6, 27, 50, 56, 95, 138, 187
formation of, xi., 123
of Cambrian rocks at Hanford Brook, xiv., 106
officers elected, xv., 144
of Geology and Mineralogy, xii., 40, 49, 69, 96, 188, 229
Secretaries' reports, xv., 133
Sectional Committee appointed, xiv., 46
officers, xiv., 100
officers, election of, xiv., 45
Sedgwick, W. T. elected corresponding member, xiii., 171
Sedimentary strata, origin of, in America, v., 78, 79
Sedum rhodantheum, viii., 78
Seismic waves, viii., 83
Self-defense, methods of animal, iii., 53–55
Self-fluxing iron ore, v., 221
Self-luminous subjects, photography of, ix., 99
Selkirk Mountains, x., 61
Seminotus, vi., 127
Senecio actinella, viii., 80
Arizonicus, viii., 80
canus, ix., 11
Douglasii, viii., 80
Fendleri, viii., 79
Hallii (new), ix., 11
Senff, Charles H., elected resident member, xiv., 220
Sensitive flames, viii., 131, 132
Separation of red oxide of zinc, ii., 26–35
Sequoia, ii., 87; iii., 6; v., 136; viii., 157
Coulteiæ, xii., 30
heterophylla, xii., 30
Reichenbachii, xii., 30
Serpentine, i., 57, 58; ii., 17; viii., 3, 48, 49, 52–54, 162; ix., 200
as building-stone, ii., 71
associated with the red hematite, at Antwerp, N. Y., xiv., 64
Staten Island, v, 228; vi., 13-16
in N. Y. Island, vi., 130–135
rocks of S. E. Penn'a., viii., 48, 49, 50
of New York Island, viii., 54
Serpentines of New York and vicinity, ix., 200
of vicinity of New York, iv., 79
Serpula, ix., 33
Setaria caudata, viii, 77; ix., 182
setosa, vii., 14
Shadow-bands in eclipse, viii., 153, 154

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Shale in northern Texas, i., 15–19
Shales indurated, at Bergen Hill, iii., 7
Shark, photograph of, vi., 70
Sharks, Carboniferous, armor of, iii., 54
notes on ancestral, xv., 40
Shawangunk grit, v., 216
Range, N. Y., glaciation of, iii., 22–30
Shell heaps, ii., 141–143
implements, i., 121, 147
Shell-mounds of Florida, viii., 164, 165
Shells, evolution in, vii., 114, 115
land, ii., 150
land, distribution in West Indies, ii., 151–154
Ship-canal at Nicaragua, viii., 165, 168, 169, 170
at Panama, viii., 165, 168, 169, 170
Ship-railroad at Tehuantepec, viii., 164–174
Ship-worms, ravages of, viii., 169
Shumardia granulosa, vii., 2
Sicydium Lindheimeri, vii., 9
Sida, viii., 77
diffusa, vii., 8
physocalyx, vii., 8
Siderite, viii., 2
Sierra Nevada, glaciation in, ii., 155
Sigillaria, ii., 50; iv., 75, 76
Signals, railway, v., 149
Significance of flora to Iroquois, v., 202
Siliceous sponge from L. I., v., 120
sinter from Yellowstone, iii., 6, 7
Silicified forest in Arizona, v., 9–11
wood from California, viii., 29, 30
from New Mexico, viii., 77
wood in Colorado, iii., 6, 7
woods, vi., 165, 166
Silurian, lower strata, v., 216, 220
Silver, ii., 94, 95; vi., 60, 64
action on ozone, v., 185
in pyrites, v., 192
ores and mines, in Col., v., 122–130
castings from Peru, iii., 15, 62, 63
chloride, iii., 1
native, iii., 2, 38
ores, processes for amalgamation, iii., 1, 2
sulphide, iii., 19
experiments upon, xiv., 180
in Lake Copper, i., 4
"King" mine, vi., 85
native, viii., 11, 160
native from Sweden, ix., 150
minerals from Potosi, S. A., ix., 154
remarkable nugget, xv., 185
Silver, Louis Mann, elected resident member, xv., 147
Sinai, desert of, ix., 110
Singing beach at Eigg, ix., 23
beach of Manchester, ii., 147, 148
beaches of the Baltic, iii., 97, 98
in Scotland and America, iii., 72–76
Siphonoglossa pilosella, vii., 12
Sirius, v., 184
Sisymbrium pinnatum, vii., 7
canescens, vii., 7
Skeletons found at Far Rockaway, ii., 140–144
palæolithic, viii., 132–135
Sketch Map of Cambrian at Hanford Brook, xiv., 108
Skulls deformed by pressure, viii., 4, 5, 6, 116
palæolithic, viii., 134, 135
Skunnemunk mountain, geology of, xi., 132
Sky Line Mine, x., 63
Skytop, N. Y., glacial striation upon, iii., 28
Slate, i., 21, 22; ii., 72, 149, 150
black, in San Juan Mts., v., 123, 129
near Nat. Bridge, v., 218
Smilacina sessilifolia, viii., 79
Smith, E. E., elected resident member, xiii., 151
Francis P., elected resident member, xii., 25
Mrs. E. A., vi., 11
Nelson, elected resident member, xi., 25
Smoke, darkening the atmosphere, iii., 60, 61
Smoky quartz, viii., 161
Snake river, Idaho, i., 4, 5
Snow peaks of Oregon, iii., 77
Soapstone at Norwich, Ct., ii., 18
Societies, vi., 167–182
etc., receiving publications of Academy, iii, 138–149; xii. at end of vol.

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Soda granite, xiv., 204
Microscopic characters of, xiv., 205
analyses of, xiv., 207
production of, v., 192, 193
Sodalite, viii., 162
from three new localities, xiii., 139
Sodium, v., 179, 186, 187, 193, 214, 215
in comet, v., 254
nitrate of, v., 214
peroxide of, v., 214, 215
sulphato-chloride, viii., 9
Soil, exhaustion by sugar-cane, iii., 15, 16
exhaustion in America, iii., 16–17
Solanaceæ, vii., 12
Solanum eleagrifolium, vii., 12; ix., 185
rostratum, ix., 185
Torreyi, ix., 185
triquetrum, ix., 185
Solar and terrestrial activity, xii., 26
eclipse of October 20, 1892, xii., 26; of 1889, viii., 153-156
Faculæ in Rutherford's photographs, xiii., 205
parallax, v., 238, 239
prominences, v., 244, 245
spectrum, v., 242–244, 245
system, evolution of, v., 249
physics, viii., 14; the bearing of electrical discharges on, xii., 48, 49
spectrum, researches on, xi., 125
"Soldier termites," viii., 90–95; 104–111
Solidago sarothræ, vii., 10
lateriflora, ix., 11
nana, viii., 80
Solidification of fluids, v., 191
Sombrero Island, dust columns at, iii., 3
Some of the sources of Bürger's Lenore, xv., 271
Sonchus asper, ix., 181
Sonometer, organ-pipe, i., 163
Sonorous sands, ii., 147, 148; viii., 9, 10, 182, 183
in America and Scotland, iii., 72–76
microscopic examination of, iii., 75
of Egypt, ix., 123
cause of, ix., 24
researches on, ix., 21, 123
Sophora affinis, ix., 184
secundiflora, vii., 9
Sorghum, v., 194
industry, iii., 5, 6
Sotol whiskey of Chihuahua, ii., 93, 94
Sound, diffraction of, viii., 130, 131
Sounds in nature, origin of, iii., 75
on beach of Costa Rica, iii., 76
Sound shadows, viii., 131
waves, viii., 130, 131; theory of, iv., 34
South Africa, crocidolite, iii., 104
America, journey in, vi., 129, 138, 147
American fishes, xiii, 110; Indian, head of, xi., 26
Carolina, phosphate beds, yield of, ix., 87
Southern Egypt, ii., 116
Spangled mica-schist, viii., 49
Spanish chestnuts, exhibition of, xi., 13
explorers, vi., 60–65
Special committees, reports of, ix., 4, 37, 70, 109
Specializations of sex in insects, iii., 103
Species of *band b* (*Protolenus* Fauna), list of, xiv., 148
of *Scirpus* and *Rhynchospora*, xi., 74
Specific gravity of amber, ii., 85
Specimens, collecting, x., 83
Spectra of comets, v., 254
of stars, v., 259
of sun, v., 242–244
of sun-spots, v., 242
Spectroscopy, viii., 14, 155
Spectrum of Gould's comet, ii., 20
Spermatogenesis of *Lumbricus* Archoplasm mass in, xiii., 135
Spermophilus Beldingi, viii., 41
Spermophila parva, n. sp., ii., 151
Sperrylite, viii., 56
Spessartite, viii., 153, 161
from Col., v., 213
Sphæralcea, viii., 77
Emoryi, viii., 79
hastulata, vii., 8
pedatifida, vii., 8
Spaæria, v., 115
Sphæriacei, v., 114
Sphalerite, iii., 23, 49; viii., 17

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Sphene, v., 77-264; viii., 21-50
Sphenophyllum, iii., 46
dimorphous foliage, iii., 46
Spherostilbite, iii., 18
Sphingina, iv., 59
Spiders of Colorado (by title), xiv., 100
Spinel, iii., 21
from Ceylon, v., 225
Spiraxis, ii., 154
major, n. sp., iii., 33
Randalli, n. sp., iii., 34
Spiræa cæspitosa, viii., 81
discolor, viii., 80
millefolia, viii., 80
Spirifer avenosus, iv., 30
arrectus, iv., 30
macropleurus, iv., 30
Spirifera macropleura, xiii., 125
Spirophyton, iii., 33
Spirulæa rotula, ii., 12
Spitzbergen, climate of, iii., 85-87
Spodumene, i., 2, 102; ii., 25; viii., 161
from Maine, vi., 40
from N. C., vii., 2, 3
Spokane mine, x., 63
Spongida of Protolenus Fauna, xiv., 112
Sporadinus ricordi, x., 52
Sporobolus, viii., 79
Spots on the sun, v., 239-242
Springs, hot, at Pagosa, Col., i., 7
soda, near Fort Worth, Texas, i., 15
salt, in Texas, i., 16
warm, x., 64
Spy, human remains at, viii., 132-135
Squid, i., 175
St. Acheul, palæolithic arrow heads, iii., 81, 82
Staffa, caves of, ii., 3-6, 37
Stalactites, ii., 39, 40
in Mammoth Cave., i., 60
Stalactitic aragonite, viii., 45
melanterite, viii., 22
Standards of time, i., 88
Standard time, v., 236
time, progress of, xi., 45
sizes for drawers and trays, xiii., 140; xiv., 65, 66, 67
Standing Committees, x., 103
Staphylinidæ, viii., 117; ix., 162
Starch, estimation by Von Asboth's method, x., 24
Star, garnets, v., 225, 226
magnitudes, x., 117
places, calculation of, x., 86
plates, Rutherfurd, x., 102
photographs, i., 146
Starr, Prof. M. Allen, elected resident member, xiv., 65
Stars, v., 257-260
about Beta Cygni, measures of, xi., 120
catalogues of, v., 257, 258
double, v., 260
parallax of, v., 259, 260
photographs of, v., 258
photometry of, v., 258, 259
spectra of, v., 259
variable, v., 259
mean declination of 56, observed for variation of latitude at Naples and New York, xiv., 87
State forests of Germany, viii., 32
Staten Island, N. Y., v., 228-230; vi., 86, 87
asbestos, v., 229
azoic rock, v., 228
Cretaceous plants, v., 28, 29
minerals, iii., 49, 50; v., 228-230
serpentine, v., 228
steatite, v., 228
buildings of, ii., 67-71
carved head found in, iii., 81
leaf-bearing sandstones, iii., 30, 31
geology of, i., 56-58; vi., 12-18; viii., 177-181
Natural Science Association, i., 67
Cretaceous on, viii., 31, 177-180
limonites of, viii., 180, 181
Quaternary of, viii., 180, 181
glacial and preglacial drift, iv., 26
stone adze from, viii., 17
Staurolite, viii., 3, 49
Stauroneis, xii., 220; xiii., 161
Steam, behavior in steam engine cylinder, i., 111-114
pipes, heating surface, i., 67-70
engines, absolute limit to economical expansion in, ii., 1
engine, development of, v., 137-143
Newcomen's, v., 137, 138
Savery's, v., 137
Watts, v., 138

Digitized by Google

Steamboat, first, on Lake Superior, iii., 13
Steatite, viii., 49, 50
Staten Island, v., 228
Stegosaurus, iii., 53
Steinmetz, Charles Proteus, elected resident member, xi., 25
Stenogyra octonoides, ii., 152
Stephanomeria Wrightii, viii., 79
Stethacanthus Altonensis, ix., 133
Stellar photometry, x., 117
Stengel, Prof. Frederick, death of, viii., 152
Stentor, phenomenon in life-history of, xiv., 49
Stereoscope, i., 9, 15, 118–120
Brewster's theory of, i., 9
Helmholtz's views on, i., 13, 14
Notes, i., 114–118
Sterility of ants and neuters, iii., 103
Stetson, Francis Lynde, elected resident member, xiv., 220
St. Eustatius, W. I., i., 23
Stilbite, ii., 89; viii., 17, 50, 57; ix., 143
Stillingia angustifolia, ix., 185
dentata, vii., 14
Torreyana, vii., 14
Stipa pinnata var. *Neo-Mexicana*, viii., 80
setigera, vii., 14; ix., 182
"St. John's" formation, vi., 113
St. John, N. B., intrusive rocks near, xiii., 185
St. Lawrence, Devonian fossil fishes from, ii., 1
Stoddard, Francis H., elected resident member, xv., 147
Stokes, James, elected resident member, xv., 147
Stone adze on Staten Island, viii., 175
age, x., 109
age tools, x., 110
durability of, viii., 175
implements from Waynesville, N. C., i., 85
perforated, from Europe, i., 49
implements at Trenton, iii., 1, 7–12
pavements, viii., 42, 43
tools, manufacture of, x., 110
Stoneham, Me., minerals from, ii., 25
herderite, iii., 37
minerals, viii., 12
bertrandite, viii., 12
beryl, viii., 12, 13, 153, 161
damourite, viii., 12
herderite, viii., 12
phenacite, viii., 13
topaz, viii., 13
Storm areas, ix., 209
Strata map, geological, viii., 129, 130
Strategic features of the Gulf of Mexico, ix., 71
Stratford, Prof. Wm., elected resident member, xiv., 68
Stratigraphical relations of Brown's Park beds, Utah, xv., 252
Stratiotes aloides, iii., 399
Street scenes in Cairo, xi., 73
Striae, glacial, on Shawangunk range, iii., 27, 28
Stromboli, viii., 82
Strombus gigas, viii., 162
Strophia, ii., 152, 153
Milleri, ii., 153
uva, ii., 152, 153
Strophodonta, Beckii, iv., 30
hemispherica, i., 57
Strophomena, vii., 2
radiata, xiii., 125
rhomboidalis, i., 57; iv., 30
Study of folk-lore, ix., 134
Sturgeon hatching in the Delaware, xiii., 69
Stylocola, ix., 34
Stylonurus excelsior, ii., 8
Stylosanthes elatior, v., 217
Suberites compacta, v., 120
Subfaunas of band B of St. John group, xiv., 105
Submarine tunnel between England and France, 155–158
Subscribers to the building fund, x., (supplement)
Subsidence and elevation, i., 22, 24 26, 28, 29, 66, 100
evidences of, x., 18
Subterranean scenery, ii., 36
Sub-surface waters, vi., 77, 91
chemistry of, vi., 90
Succession of animal life, iii., 20
of forest growths, iii., 36
Succinea gyrata, ii., 151, 152
Sucrose, dextrose and levulose, xi., 126

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Sugar beet cultivation, iii., 5, 6
Cane crop, soil exhaustion by, iii., 15, 16
from sorghum, iii., 5, 6
Sugar, maple, sap-sand, i., 167
Suggestions as to the determination of the relative mass of the two components of the double star Eta Cassiopeiæ from Rutherfurd photographic measures, i., 35
method to be pursued and formulæ to be used, xv., 35
Sium cicutæfolium, iii., 42
Sullivan County, N. Y., moraine deposits, iii., 25, 26
Sulphides of silver, etc., v., 128
Sulphohalite, viii., 8, 9, 22
Sulphur, v., 195
dioxide of, v., 185
springs in the desert of Sinai, ix., 121
deposits in Utah and Nevada, i., 168–175
Sulphuretted hydrogen, v., 187
Sulphuric acid, v., 186, 187, 192
Summer experiences of Prof. Mayer, xiv., 7
Summit meteorite, cuts of, ix., 196
meteorite, analysis of, ix., 197
Sun, v., 238–247
and meteorology, v., 239
atmosphere of, v., 240
corona of, v., 245–247
chromosphere, v., 245
distance of, v., 238, 239
eclipse of, v., 245, 246
heat of, v., 240, 241
parallax of, v., 238, 239
prominences of, v., 244, 245
spectra of, v., 242–244
surface of, v., 239–242
Sunapee Saibling, xii., 139
Sun-photographs, i., 145
Sun-spots, ii., 35; 239-242
spectra of, v., 242
penumbras of, xiv., 77
pictures of, xiv., 78
Sun, total eclipse of, ix., 5, 47, 52
Surface deposits, x., 8
of fossil resins, viii., 157, 158
of sun, v., 239–242
Surgery, use of trance in, ii., 66
Surivella, xiii., 101
Survey at Lake Mœris, iii., 78, 79
Geodetics, United States, iv., 1
of United States, Trigonometric and Topographic, iv., 58
Survey, Van Rensselaer canal, xi., 45
Sussex County, N. J., ores and minerals, ii., 25
Swash, x., 6
Sweet Grass Hills, x., 57
Syenite, elaeolite, xi., 60
Sylviidæ, vi., 139
Symbols, alchemical, ii., 102–104
chemical notation, ii., 53–59
Synclinal fold in Page Valley, v., 216
Synthesis, chemical, v., 197
Synthyris Plantaginea, viii., 80
Systems of mechanical units, xv., 34
Introduction by Fourier, xv., 34
System of recording field notes, xv., 191

Tabasheer, viii., 158, 159
Table of chemical characters, ii., 56
Table-land of New Mexico, viii., 77
Tachypetes aquila, vii., 83
"Taconic system," vi., 138
Tadpoles, cloacal aperature of, xii., 242
Tails of comets, v., 251–255
Talc, v., 229; viii., 53
deposits near Gouverneur, N. Y. (origin of), xv., 154
schist, i., 56–58
serpentine and tremolitic minerals, association of, iv., 77
white, from Gouverneur, N. Y., iv., 77
Talinum aurantiacum, vii., 8
lineare, vii., 8
patens, ix., 181.
Tamborrel, J. de M., elected corresponding member, xii., 25
Tamarisk, vii., 170
Taraxacum, viii., 79
Tasmania, tin of, viii., 148
Tatlock, John, Jr., elected Curator, xii., 128
Tattooing among Indians, viii., 115, 116
Taxodium, iii., 85
distichum, ix., 31
Tehuantepec ship-railway, viii., 164–174

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Telescopes of the world, vi., 93–107
construction of, vi., 95–105
lenses of, vi., 96–103, 107
Lick, vi., 100, 105, 107
origin of, vi., 93–95
reflectors of, vi., 103–105
size of, vi., 105–107
Teleosts of the Cretaceous period, iii., 54
Tellurium in copper products from Col., i., 4
Temperature, annual, ix., 206
annual, in Egypt, ix., 111
daily in Egypt, ix., 111
effect on chemical changes, v., 186, 187
lowest measured, v., 191
Mammoth Cave, i., 59
of the Earth's crust, xii., 186
of incandescence, iv., 43
Temples and palaces of Yucatan, v., 169–178
Tendencies of recent electrical research, xiv., 153
Tendon, capsular-intermediate, xiv., 250
capsular-pectoral, xiv., 241
gleno-epitrochlear, xiv., 247
Tenerium laciniatum, ix., 185
Tennessee meteorite, vi., 160; viii., 187
Tenorite, viii., 45
Ten years progress in astronomy, v., 234
Tephroite, ii., 34
Terebratula plicata, ii., 10
Harlani, ii., 85
fragilis, ii., 11
Teredo navalis, viii., 169, 170
Termes, viii., 87
testaceus, viii., 86, 97–99, 108; ix., 159
albidus, ix., 161
bellicosus, ix., 177
columnaris, ix., 158
lucifugus, ix., 158
minimus, ix., 158
prælongus, ix.,160
saltans, ix., 172
Termitogaster insolens, viii., 117; ix., 163
Termitariums, vii., 100–113
Termites, viii., 85–114
of the Isthmus of Panama, ix., 157
Termitophilous beetle, viii., 117
Terraces on Shawangunk Mountain, iii., 27
Terrestrial molluscs, ii., 150–154
in the West Indies, i., 181
Tertiary age., v., 133
climate in Arctic regions, iii., 94
plants, found in Colorado, iii., 13, 77
present range of, iii., 96
strata, i., 21, 22
fossil plants, xi., 123
Testing iron and steel, commission for, i., 49
safety of kerosene oil, i., 138–143
Texan botany, contributions to, ix., 181
Texas, botany and geology, ii., 66, 90–95
coal, i., 15, 16
copper region, i., 15–20
gypsum, i., 17
pumice tuff, i., 52
meteorite from, viii., 186
yttrium, minerals in, viii., 159, 185
Thalamorphora, ix., 33
Thalassema, history of the Achromatic structures, xv., 163
the egg centrosome, xv., 164
the sperm centrosome, xv., 168
the cleavage-figure, xv., 170
effect of fixing agents, xv., 172
literature referred to, xv., 175
description of plates, xv., 175
Thalictrum Wrightii, viii., 78
Thames River, England, water of, iii., 42
Thamnosma Texanum, vii., 8; ix., 182, 183
Thecocilio flagellata, ix., 33
Theco flagellata, ix., 33
The determination of division errors in straight scales, xv., 63
Etymology of Italian *andare* and related words, xv., 271
Thelephora domestica, v,, 110
Thelysperma filifolium, ix., 182
longipes, ix., 184
trifida (new), ix., 182
"The Tradition of the Case-Forms in Chaucer's Noun," xv., 271
Thermo-chemistry, v., 189
Thermodynamical phenomena, ix., 138

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Theories concerning Great Pyramid, ii., 114–116
etc., of virus, v., 204–213
of musical sand, x., 33
Theory of the origin of leaf forms, iii., 38–44
Thetis' hairstone, viii., 161
Thinnfeldia, xii., 33
Thin sections of rocks, i., 49–53, 154
Thiophene, v., 195
Thompson, Prof. W. Gilman, elected resident member, xiv., 93
J. P., elected corresponding member, xiii., 23
Thorium phosphate, viii., 8
Thousand Islands, diabase dikes of, xiii., 213
Thread-fins, ix., 15
Thrush, new species, vi., 111
Thuja, v. 136; vi., 126
occidentalis, v., 218
Thulium, v., 181–200
Thurberia Arkansana, vii., 14
Thymolesulpho acid, i., 3
Tides, cause of, viii., 187
high, erosion by, i., 80–85
"Tide-water" gneiss, v., 19, 20, 222
Tideways of Puget Sound, origin of, iii., 104
Ties, iron, railway, v., 152
Timber, decay in, v., 110–120
Time, standard of, v., 236
signals, v., 158
system for observatories, v., 158–162
international, i., 86–95
rate in chemical affinity, v., 188, 189
Timmins, Mr. Samuel, viii., 23
Tin deposits of Black Hills, Dakota, iv., 44
indications of, ii., 100
in San Juan Mts., v., 128
mining in Cornwall, viii., 149
of Australia, viii., 147
of California, viii., 150
of Dakota, viii., 146, 148, 150
of East Indies, viii., 149
of Mexico, viii., 150
of North Carolina, viii., 136–151
Titanichthys, v., 27
Agassizii, v., 27; vi., 164, 165
Clarkii, vi., 164, 165
Titanium in iron-ores, ii., 7, 14, 17
Titanotheres in Am. Museum, xv., 66
skull structure, xiv., 62
Titanotherium and Metamyodon skeletons in Am. Mus., xv., 40
Titanite, ii., 24
yellow (gem), viii., 21
Toltec images, ix., 97
Toluca, meteorite, vi., 70
Tombstones, durability of, ii., 75
Tonquieria splendens, ii., 92
Top, autograph of, vi., 135
Topaz, ii., 25, 42, 100; iii., 2, 13, 37; ix., 149
from Colorado, v., 213
from Texas, xii., 96; xiv., 144
North American, viii., 160
Topographical map of State, preparation of, xiv., 91
Topography of Egypt, iii., 78, 79
of North America, iii., 51–52
Tornadoes, iii., 3–5
Torpedoes, xii., 151
Torrey Botanical Club, Field Day, iv., 5
Tourmaline, i., 2, 101; ii., 25; iii., 34, 49; v., 74, 80, 121, 222, 264, 266; vi., 77; viii., 161
black, from St. Lawrence Co., N. Y., iv., 57
crystals from Rudeville, N. J., xiii., 185
Toxopneustes, xiv., 185
fertilization, phenomena of, xiv., 99
Trachelomonas, ix., 33
Trachosteus, xii., 70
Trachyte, i., 19, 23, 169; ii., 94
in San Juan Mts., v., 122–130
Track inspection car, iv., 5
Tracks, in Triassic, vi., 125
Tradescantia Virginica, ix., 182
Tragia ramosa, vii., 14
stylaris, vii., 14
Trogophlæus, viii., 41
Trance, treatment of sea sickness, ii., 64–66
state, artistic uses of, iii., 107
Transactions, vi., 66
price of, x., 1
Transformation of peat, i., 71–76
of skin, vi., 113
Transit factors for Observatory of Columbia College, xi., 41
observations by least squares, reduction of, xi., 25

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Transit of Venus, ii., 51–52;v., 238
Transmutation of metals, ix., 72
Trapa microphylla, ix., 30
Trap, ii., 71, 72
  Columnar, Orange, N. J., iv., 4
  dikes in the Adirondacks, xv., 248
  in the Lake Champlain valley, xi., 13
  of Champlain, xv., 20
  in East Tennessee, v., 220–222
  in Staten Island, v., 230
  of Palisades, ii., 117–120
  pavements, viii., 42
Trays for cabinets, moulded, xiii., 140
Treasurer, report of, iii., 69; viii., 125, 126; ix., 106, 107; xiv., 88; xv., 130
  receipts, xv., 130
  disbursements, xv., 131
Tree culture, viii., 36, 37, 40
Trees in cities, v., 264
  planting and destruction of, iii., 35–37
Trematobolus insignis, xiv., 122
Tremolite, ii., 149; iii., 49
Tremolite, i., 58
Trenton limestones in Champlain valley, xiii., 115, 225
Trenton, N. J., stone implements at, iii., 1, 7–12
  rocks, viii., 48
Trial of building-stone, methods, ii., 75, 76
Triarthrus Beckii, antennæ of, xii., 237
  with appendages, viii., 109
Trias of America, v., 17, 18, 19
  of South Africa, v., 20
  reptilian foot-prints in, v., 72
Triassic coals, metamorphism by diabase dikes at Egypt, N. C., xv., 105
  copper ores, iii., 18, 19
  fossils at Weehawken, N. J., v., 17
  four-toed tracks, xii., 188
  of New Jersey and Connecticut, vi., 124–128
  of Staten Island, vi., 16
  of Penn., viii., 47, 56
  sandstone, ii., 117–120
  strata, i., 20
Tribally organized societies, study of, F. H. Giddings, xv., 155
Tribes of British Columbia, viii., 3, 116
Tribolos, iv., 40
Tribulus maximus, ix., 181, 183
Triceratops, ix., 31
Trichloris pluriflora, vii., 14; ix., 182
Trifolium, iii., 39; viii., 79
Trilobita of Protolenus Fauna, xiv., 138
Trilobite, i., 7; ii., 38, 107; vi., 113, 122
Trilobitic fauna of Cumberland head, xv., 21
Trinucleus concentricus, vii , 4
Trinidad, pitch lake of, viii., 26
Trinomalism, x., 81
Triodia acuminata, iv., 182
  albescens, iv., 182
  eragostoides, iv., 182
Toiphylite, ii., 25, 42
Triplite, ii., 25
Tripoli interstratified with volcanic ashes, i., 55
Trips through marble quarries of western, northeastern and eastern New York, xv., 188
Trochilia, ix., 34
Trochosmilia conoides, ii., 12
Troglodytidæ, vi., 139
Troilite in meteorite, vi., 76, 92, 144, 145
Tropical calms, viii., 168, 169
Tropical birds, habits of, xiv., 66
Trowbridge, Wm. P., death of, xii., 2
Troximon glaucum, viii., 80
Tubes of earth by cicada, v., 121
Tubercular disease, prevention of, i., 181
Tuckerman, Alfred J., elected resident member, xii., 25
Tudora, ii., 151–153
  megacheila, 151
  versicolor, 152
Tuning Forks, method of comparing pitch of, xiv., 76
Tunnel between England and France, i., 155–158
Turba of Brazil, i., 76
Turquoise, ix., 148; viii., 3, 7, 162
  Indian ornaments of, 162
Tuscarora Indians, ii., 58–60
Tyrannidæ, vi., 139; ix., 34
Tyringham, Mass., spherostilbite and chabazite, iii., 18

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Tyrosin, v., 197
Twins and multiple embryos of *Amphioxus*, xii., 17

Ulmus, iv., 31
Ulster Co., notes on geology of, xiii, 165
Umbelliferæ, iii., 47; vii., 10
Umbelliferone, v., 197
Ungnadia speciosa, ii., 92
Uniformity of geological climate, iii., 84–97
Unio, ii., 142; v., 17; viii., 163
United States, geodetic survey, iv., 1
Phalangidae of, xi., 125
Unrecognized families of larvæ, xiv., 61
Ural Mountains, minerals, gem sand ethnology of, xi., 119
Uralium, v., 200
Uraninite, viii., 185
Uranium glass, experiments upon, xiv., 169
Uric acid, v., 197
Urodela, vii., 256
Uronychia, ix., 34
Urticaceæ, vii., 14
Urtica chamædryoides, vii., 14
Urticariæ, v., 37
U. S. eclipses, expedition to South Africa, x., 2
Use of trance in surgery, ii., 66
proposed for alchemical symbols, ii., 54–56
Utah, iron ores, ii., 15
ozokerite, ii., 46
luminous limestone, iii., 100
sulphur-deposits, i., 168–172
Utica shales in Essex Co., N. Y., xiii., 226
Utricularia cleistogama (new), ix., 12
subulata cleistogama, ix., 12

Vaccinium Canadense, ix., 11
corymbosum atrococcum, ix., 11
disocarpum, ix., 11
disomorphum (new), ix., 11
fuscatum, ix., 11
Pennsylvanicum, ix., 11
Vacuum discharges, xi., 72, 124
pump, automatic mercury, xiv., 78
Vaginicolæ, ix., 34
Vanadinite, iii., 100
Vanadium, v., 192
Vancouver's Island, v., 133; ix., 2
Vanilline, v., 197;
Van Ingen, Gilbert, elected resident member, xv., 124
Van Nardroff, E. R., elected resident member, xv., 63
Van Rensselaer canal survey, xi., 45
Variable stars, v., 258
Variation of decomposition in pyrites v., 231
Varieties of new red sandstone, v., 12
Vaseline, v., 194,
Vaughan, Miss Virginia, elected resident member, xi., 25
Vegetable cells on obelisk, v., 63, 68
remedies of Indians, v., 202–203
Vegetation, effects of, on the surface, x., 14
in cities, etc., v., 264
Veins in N. Y., gneiss, viii., 54
metal bearing, in Colorado, v., 122–130
Velocity of light, v., 239
Velutinas, v., 53
Venation of leaf, relation to marginal forms, iii., 41
Venericardia perantiqua, ii., 12.
Ventilating chimneys, i., 67–70
Ventro-appendicular muscular sheet, intermediate layer, xiv., 233
deep layer of, xiv., 233
superficial layer of, xiv., 233
Venus alveata, ix., 88
mercenaria, ii., 141
Venus, v., 248
transit of, ii., 51, 52; v., 238
satellite of, v., 249
Verbena bipinnatifida, ix., 181
canescens, vii., 13; ix., 185
ligustrina, ix., 181
ciliata, vii., 13
officinalis, vii., 13
polystachya, viii., 80
Verbenaceæ, vii., 13
Verbesina, viii., 77
encelioides, vii., 11; ix., 184
Virginica, vii., 11
Vermes, v., 32–55
Vermont marbles, iii., 100, 101
Vertebrata, v., 32
evolution of, ii., 64
Vesbium, v., 200
Vescaria Fendleri, vii., 7
lasiocarpa, vii., 7

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Vibration of a chord, xv., 135
Viburnum, ix., 31
Bridgetonense, iv., 31
Vicia exigua, vii., 97
Vigniera, viii., 77
Vinegar plant, vi., 60–70
Violaceæ, vii., 7
Violane, ix., 145
Virginia, geology of S. W. (title), vi., 113
minerals from, iii., 77, 100
southwest, mineral resources of, i., 159–163
Virgin Is., W. I., breccia, i., 21
Virus, mitigated, v., 204–213
"Visible Wind," viii., 154
Visceral Anatomy, xv., 98
Myrmecaphaga jubata, xv., 98
Tamandua bivittata, xv., 98
Arctopithecus didactylus, xv., 98
Dadypus sexcinctus, xv., 98
Tatusia novemcincta, xv. 98
Manis longicaudata, xv., 98
Vitis incisa, vii., 9
heptaphylla (new), ix., 10, 183
rupestris, ix., 183
quinquefolia, ix., 10
Vivianite from New Jersey, ii., 13
Vivier, Ernest du, elected resident member, xi., 25
Vivisection in the District of Columbia, resolutions on, xv., 272
Vocal chords in voice production, action of, xv., 2
photographs of, in action, xv., 2
Volborthella tenuis, xiv., 132
Volcanic action, vi., 28, 29
air wave, viii., 83
ash, i., 23, 49–56, 169, 171, 172
ashes in Yellowstone Park, iii., 6
ashes, microscopic examination of, iii., 14, 63–64
dust of Krakatoa, diffusion of, iii., 60–61, 54–65
comparisons, xiv., 209
phenomena, iv., 54
Volcano on moon, v., 237
Volcanoes, vi., 28, 29, 37
origin and distribution, viii., 82
Volts and ampères, and what they mean, ix., 137
Von Asboth's method for estimating starch, x., 24
Vorticellidæ, ix., 34
Votes of thanks, xv., 133
Votive adze, vi., 139
"Vulcan" (planet), v., 247, 248
Vulté H. T., elected Curator, xii., 128
Librarian, xi., 25

Wad, ii., 18
Wade, Herbert T., elected resident member, xiv., 220
Wadi Werdân, ix., 23
Wadis, ix., 120
Wagon Wheel Gap., Col., i., 7
Walcott, C. D., on Cambrian, viii., 176
Wall at Chatata, Tenn., ancient inscription on, xi., 26
Ward, Delancey W., elected resident member, xii., 99
Warm Arctic climate, ancient, iii., 84–86
springs, x., 64
Wasatch Mts., Utah, copper ores, iii., 19
Wasatch range, glaciation in, ii., 155
Water, analysis of, vi., 42, 49, 53
analysis, condenser for, xii., 54
bath of copper, xiv., 79
carbonic acid in, iii., 42
of River Thames, England, iii., 42
(chemical), v., 196
contamination of, vii., 117–125
of the Nile, ix., 120
of the desert, ix., 121
organic matter in, ii., 111–114
spouts in Caribbean Sea, iii., 3
supply of N. Y.. viii., 117–125
supply, purification of, vi., 42–58
sub-surface, vi., 77–91
Waves, destructive action of, ii., 4
Wavellite, iii., 18
Weehawken tunnel, minerals, i., 129–131; ii, 88–90
Weight of atoms, v., 182, 183
Weir, Robert, elected resident member, xi., 123
West Farms, rocking stone at, xi., 13
West India Islands, distribution of terrestrial molluscs, i., 181
geology, i., 21–24
Westchester Co., N. Y., rocks of, viii., 50, 51
West End Nat. Hist. Assoc., viii., 46

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Western minerals, notes on, v., 213, 214
Weston, Th., elected resident member, xv., 147
"Wet rot" in wood, v., 114
Whale captured off Montauk, i., 147
Wheels, paper railway, v., 152
White ants, viii., 85–114
River deposits, mammals from, xiii., 176
White, T. G., elected resident member, xiii., 151
White, Thaddeus R., elected resident member, xv., 147
Whitfield, R. P., elected Councillor, xii., 128
Whiton, Louis C., elected resident member, xv., 147
Wichita Mountains, Texas, i., 19–20
Whiddingtonitis Reichii, xii., 30
Widmanstättan figures, v., 224
Wild plantain from Panama, vi., 112
Willemite, ii., 26–30; viii., 162
Willey, Arthur, elected resident member, xii., 25
Williamsbridge, N. Y., pot holes, i., 181–183
Williamsite, viii., 162
Williamsonia Riesii, xii., 37
Will of Mme. Goguet, xi., 2
Willsboro' township, geology of, xiii., 214
Wilson, Edmund B., elected resident member, xii., 25
Winding apparatus, etc, v., 153–157
Winds, v., 230
in the desert, ix., 114
Winnebago arts, x., 39
meteorite, ix., 201
meteorite, analysis of, ix., 202
Witchcraft excitement, explanation of, i., 150–153
Withering, Dr. William, citation from, viii., 24, 25
Wire, corrosion of, iii., 65, 66
Wm. Maclure's Geology, xi., 45
Wöhler, Prof. F., memorial of, ii., 2
Woman's part in the earlier civilizations, xi., 29
Wood, decay of, viii., 85, 86, 89
chemical composition of, v., 116
decay of, v., 110–120
preservation of, v., 118–120
opal, viii., 30
phosphorescent, x., 37
sections, photo-micrographs, iii,, 107
Wooden pavements, viii., 43
Woods, silicified, vi., 165, 166
silicified, in Colorado, iii., 6, 7, 13, 77
Woodward, R. S., elected resident member, xiii., 23
Wollastonite, viii., 162; ix., 145
from New York State, xiii., 146, 207
Wool, natural dyes as applied to, xi., 157
World's Fair of 1892, ix., 4
Wortman, J. L., elected resident member, xii., 25
Wulfenite, viii., 177
Wurtz, Prof. Henry, viii., 180, 181
Wyoming, fossil fishes from, iii., 34, 38
minerals from, iii., 7, 19, 20, 101

Xenacanthus, xii., 123
Xenotime, viii., 159
'X' (new element), v., 200
X-rays experiments, by Prof. Pupin, xv., 136

Yα (new element), v., 200
Yβ (new element), v., 200
Yellow Day (Sept. 6, 1881), i., 1
atmospheric phenomena, i., 1
drift, iv., 26
sapphire, xi., 58
Yellowstone Park, Wyo., geology, botany, etc., iii., 34
geysers and rhyolite, iii., 7
Yolk nucleus, literature on, xiv., 229–230
Ytterbium, v., 181, 200
Yttrium minerals in Texas, viii., 159, 185
Yucatan birds, v., 17, 55
temples and palaces, v., 169, 178
Yucca, iii., 39, 47
angustifolia, ii., 93; viii., 76
baccata, ii., 93; viii., 76

Zα (new element), v., 200
Zβ (new element), v., 200
Zamia, iii., 85
Zamites Fenconis, vii., 115

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Leggetti, vii., 114, 115
occidentalis, vii., 114
Rolkeri vii., 114
Zaphrentis calceola, vii., 247
prolifera, i., 57
Zempoaltepetl, volcano of, viii., 44
Zeolites, ii., 154–155; iii., 1, 78
Zephyranthes Andersonii, vii., 14
Zero-meridian for standard time, i., 93, 94
Zeuglodon, xiii., 15
Zexmenia hispida, ix., 181–184
Zigadenus elegans, viii., 78
Zinc, v., 123, 186
and lead mines in southwestern Virginia, xv., 61
oxide, artificial, xiii., 208
red oxide, ii., 26–35
Zincs, new form for Bunsen batteries, x., 114
Zincite, ii., 26–35; v., 128
from Franklin Furnace, N. J. xiii., 184
Zinnia pumila, ix., 184
Zircon, ii., 325; iii., 17, 107; vii 8
Ceylonese, penetrated by rut iv., 59
Zizania, iv., 31
Zizyphus obtusifolia, ix., 183
Zonites, i., 181
new species of, i., 181
petrophilus, n. sp., ii., 150
Wheatleyi, n. sp., ii., 150
Zoölogy, invertebrate, v., 29
Zγ (new element), v., 200

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PLATE I.

Geological Map of the Vicinity of Glacier Bay, by H. F. Reid and H. P. Cushing.

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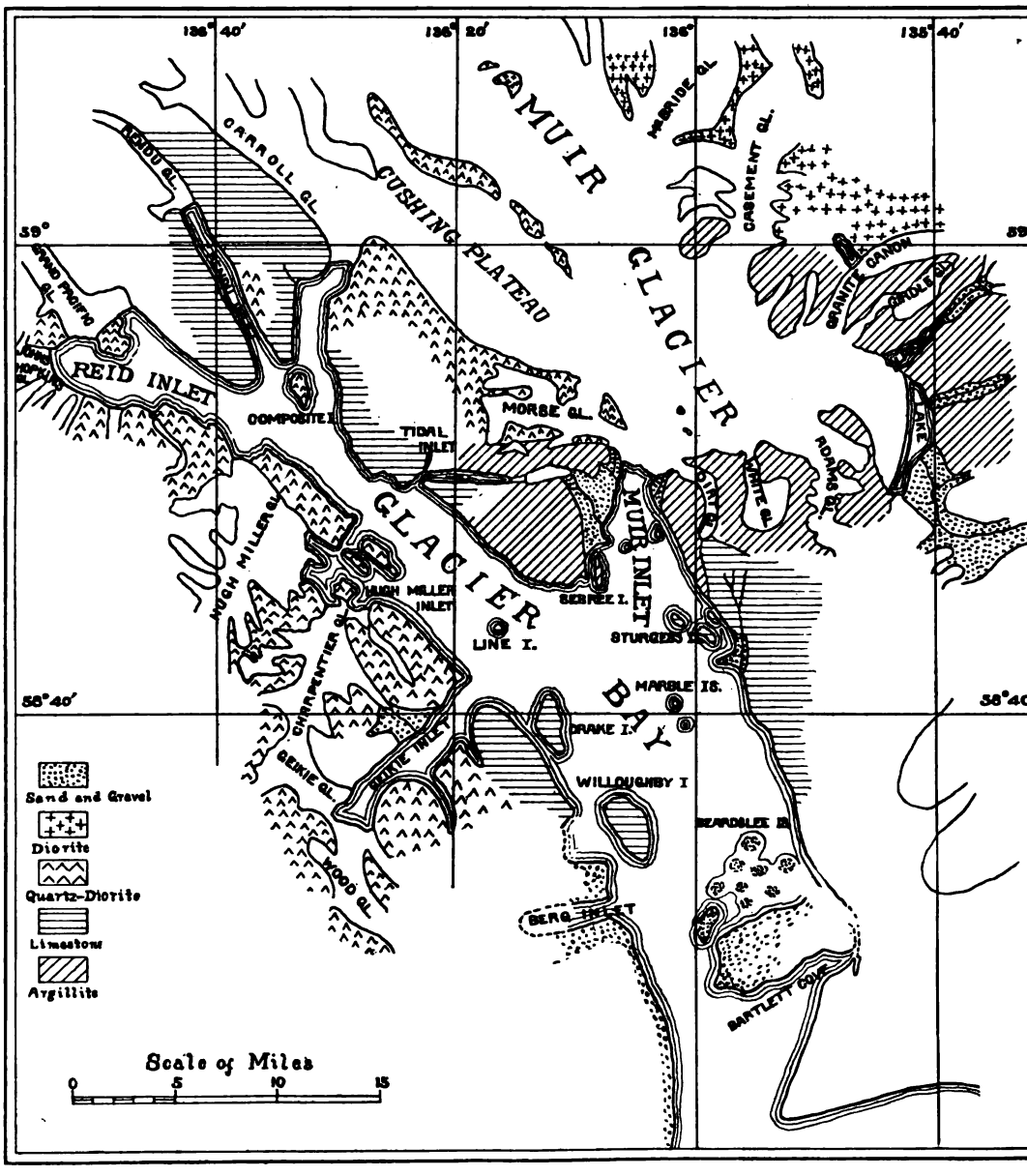

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PLATE II.

View of Sherman Fall, Kauya Hoora Gorge, Trenton Falls, N. Y. Photographed by Theodore G. White, November, 1895. The lower of the two black seams shown in the fall is D 7, the upper is D 9; while the layer D 11, again shown in Plate IV, figure A, is seen just above the top of the main volume of the fall on the left hand side. The underlying layers are shown nearly down to D 1.

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PLATE III.

Fig. A. Undulations in layer (D 15) between lower and upper portion of the Great Fall, Kauya Hoora Gorge, Trenton Falls, N. Y. Undisturbed horizontal layers are seen both above and beneath. Photographed by Theodore G. White, November, 1895.

Fig. B. Overlap structure of bedding of Trenton limestone, on east bank of West Canada Creek, in "Rocky Heart," Trenton Falls, N. Y. The lower portion in the view is covered by water. Photographed by T. G. W., November, 1895.

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FIG. A.

FIG. B.

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PLATE IV.

Fig. A. Constant heavy blue black, layer (D 11) with adjacent thin layers, lying just above Sherman Fall, Kauya Hoora Gorge, Trenton Falls, N. Y. Photographed by Theodore G. White, November, 1895.

Fig. B. Example of channel filling, in D 22, north of railroad bridge, Kauya Hoora Gorge, Trenton Falls, N. Y., on west bank. Corresponding example shown in the following plate. Photographed by T. G. W., November, 1895.

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FIG. A.

FIG. B.

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PLATE V.

Fig. A. Upper end of Kauya Hoora Gorge, Trenton Falls, N. Y., embracing the upper third of the Trenton limestone, from D 18 to D 23. Exhibits black thin bedded limestones below, and above them the heavy gray crystalline capping. Photograped by Theodore G. White, November, 1895.

Fig. B. *Palaeospondylus gunni*, Traquair $\times \frac{1}{10}$. From drawing with Abbé camera. BW, line indicating the marginal body wall. PO, postoccipital plates of Traquair. RS, radial-like supports (of paired fins). To illustrate paper by Bashford Dean, p. 101.

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FIG. A.

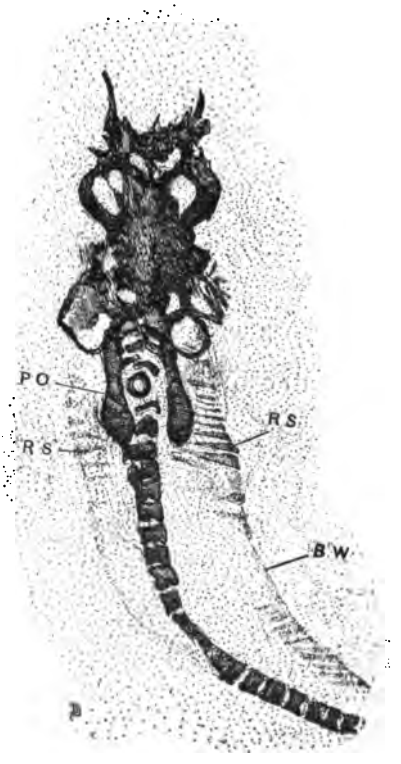

FIG. B.

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PLATE VI.

Varietal Tree of a Philippine Pulmonate, *Cochlostyla ovoidea*. To illustrate paper by F. B. Sumner, p. 137.

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PLATE VII.

Dinichthys gouldi, Newberry ; $\times \frac{3}{4}$. A specimen showing vertebral axis, ventral armoring and bases of dorsal and of ventral fin. From the collection of Dr. William Clark, Berea, Ohio. AV, Anterior ventral. C, Coprolite. D F, Basalia of dorsal fin. H A, Haemal arch. H S, Haemal spine. L P V, Left posterior ventral. N A, Neural arch. N C, Notochord. R P V, Right posterior ventral. U, Plates of unknown position (perhaps posterior laterals (Traquair) of Coccosteus). V F, Basalia of ventral fin (?). V G, Pelvic girdle. V M, Ventro-median.

(The plates L P V, R P V, and portions of C, U and V F were attached to the right half of the concretion. They are here shown as if attached to the opposite half of the concretion : they thus appear in their actual position, but in reversed aspects.)

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PLATE VIII.

Restorations of ventral armoring of Coccosteids.

FIG. 1. Coccosteus decipiens, Ag. After Traquair; × about $\frac{2}{3}$.

FIG. 2. Dinichthys gouldi, Newb. × about $\frac{2}{3}$.

FIG. 3 Dinichthys terrelli, Newb. After A. A. Wright; × about $\frac{1}{12}$.

A V M, Anterior ventro-median. I L, Inter-lateral (? clavicle). L A V, Lateral anterior ventral. L P V, Lateral posterior ventral. P V M, Posterior ventro-median. R A V, Right anterior ventral. R P V, Right posterior ventral. V M, (Posterior) ventro-median.

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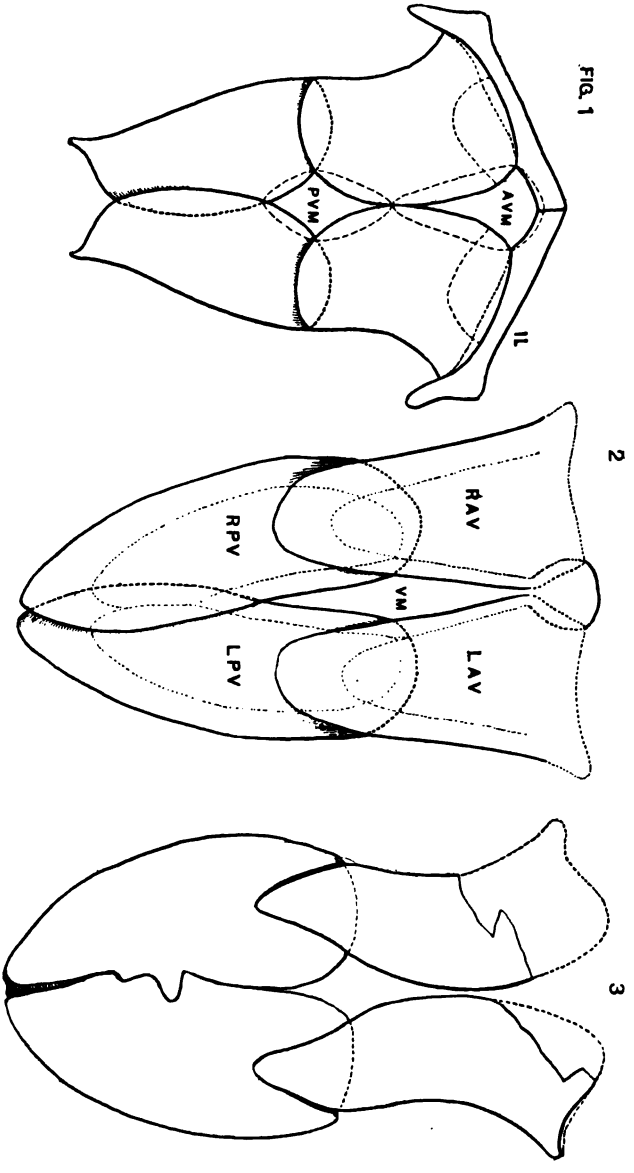

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PLATE IX.

ILLUSTRATING THE PAPER OF BRADNEY B. GRIFFIN, p. 163.

FIG. 1. The egg ten minutes after fertilization, showing the minute asters and their focal centrosomes, also the large black nucleolus.

FIG. 2. Somewhat later stage several tetrad groups have been already formed.

FIG. 3. The same stage, showing variation in relation of asters to nucleus.

FIG. 4. Much later stage. The tetrad groups have now been established, leaving a mass of discarded chromatin. The sperm head is shown at ♂.

FIG. 5. First polar spindle during halving of tetrads. Sperm head at ♂.

FIG. 6. First polar telophase. Sperm head and aster (♂).

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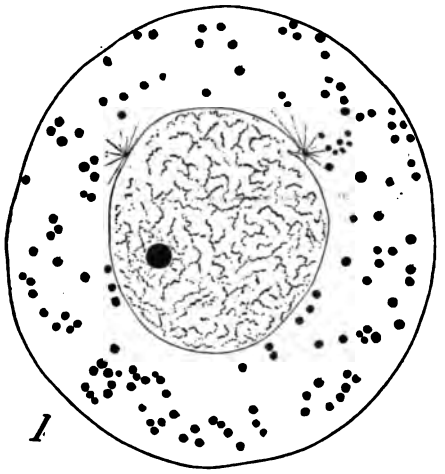
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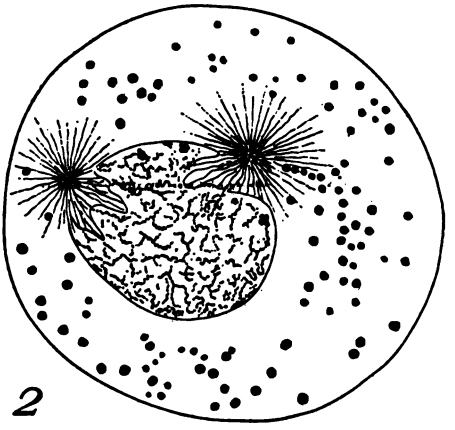
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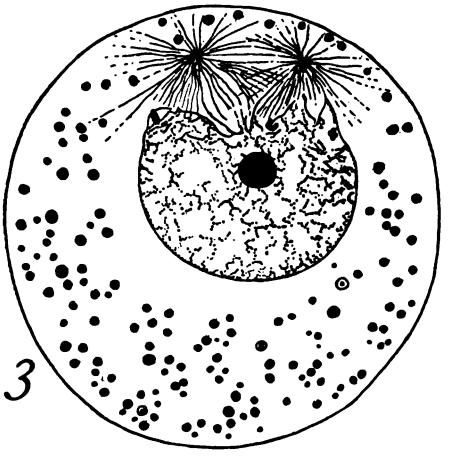
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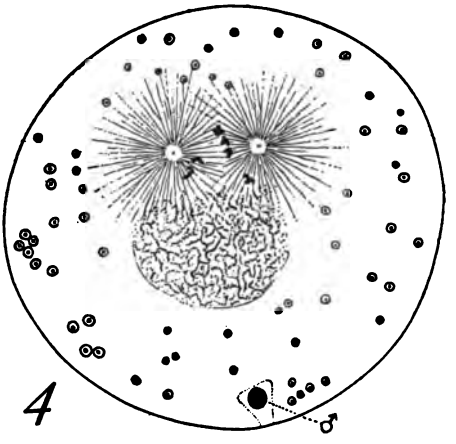
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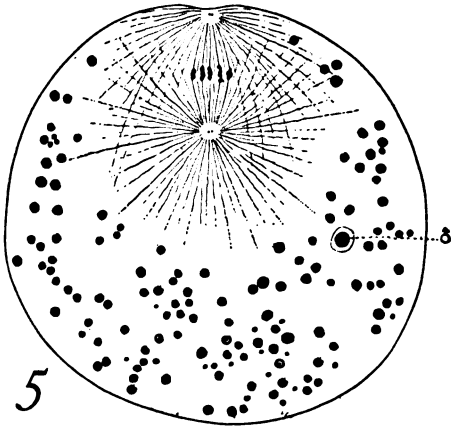
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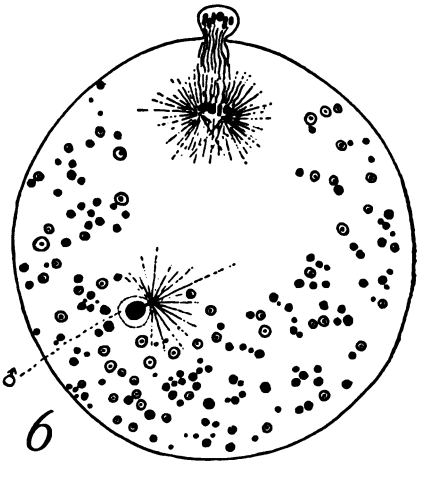
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PLATE XI.

ILLUSTRATING THE PAPER OF BRADNEY B. GRIFFIN, p. 163.

FIG. 13. Fully formed first cleavage figure, showing centrosomes already divided and surrounded by the darker area, nearing the periphery of the centrosphere.

FIG. 14. Commencement of anaphase. Centrosomes or periphery of centrosphere.

FIG. 15. Stage just previous to mid anaphase, minute amphiaster forming about the centrosomes.

FIG. 16. Mid anaphase, amphiaster elongated.

FIG. 17. Vesicles previous to fusion.

FIG. 18. Vesicles fusing.

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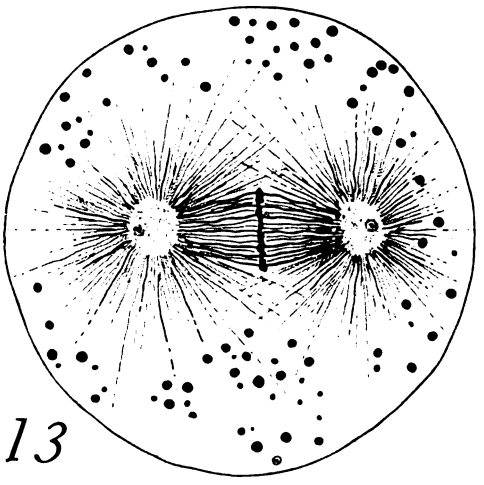

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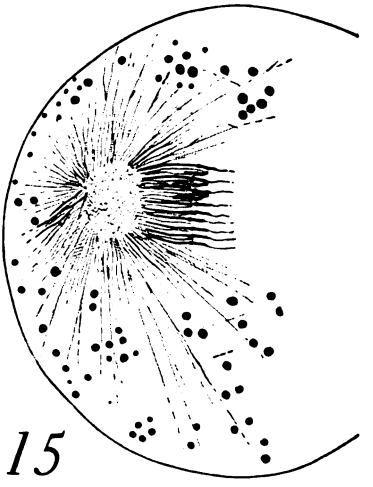

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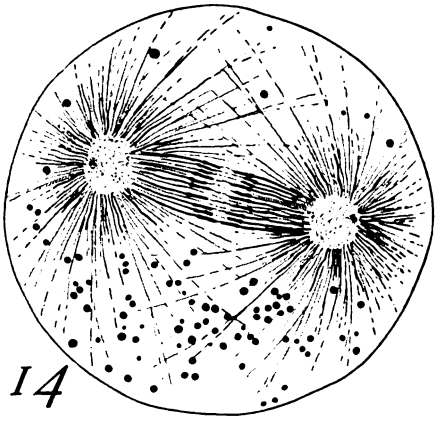

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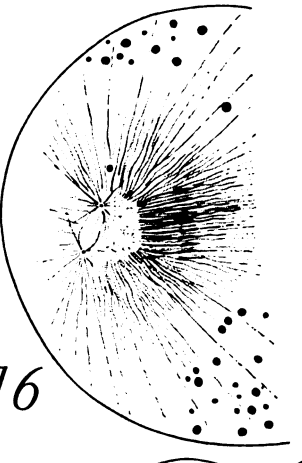

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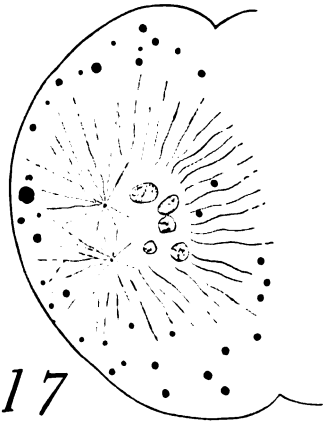

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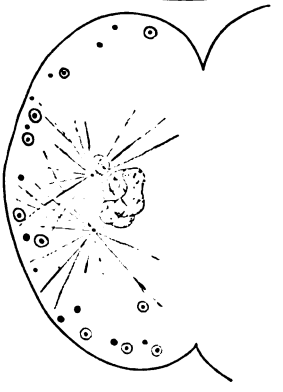

18

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PLATE XII.

ILLUSTRATING THE PAPER OF WARREN H. EVERETT, p. 176.

FIG. 1. The membranous ear as seen from the outside at nearly right angles to the side of the head and a little above. It shows the shape and position of the sacculus (s.), utriculus (u.), lagena (l.) and their relation to each other: also the position of the ampullæ with respect to the canals and the recessus utriculus (r. u.). d. c. p. represents the small connecting tube between the connecting tube of the posterior canal (p. c. t.) and the sacculus (s.).

FIG. 2. The membranous ear as seen from the inside at right angles to and on a level with the head. It shows the position of the ductus endolymphaticus (d. end.) and its relation to the sacculus (s.), utriculus (u.) and the recessus utriculus (r. u.). It also shows the position of the utriculus (u.) with respect to the recessus utriculus (r. u.) and the ampulla of the anterior canal (a. a.). The two dotted lines that extend from the ramulus of the posterior ampulla to the ductus canalis posterioris (d. c. p.) show the course of the ramuli of the macula neglecta. (m. n.) marks the macula.

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Fig. 1.

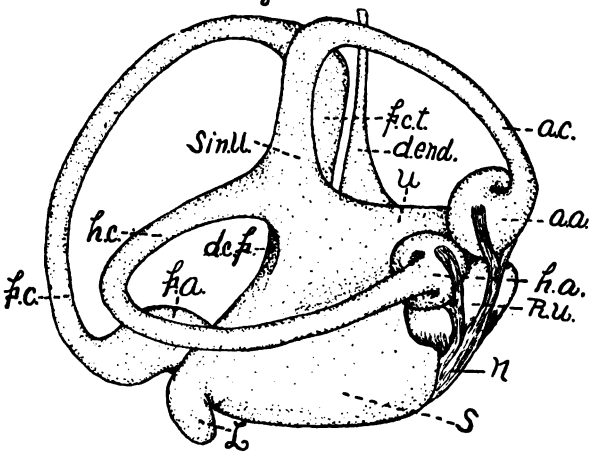

Fig. 2.

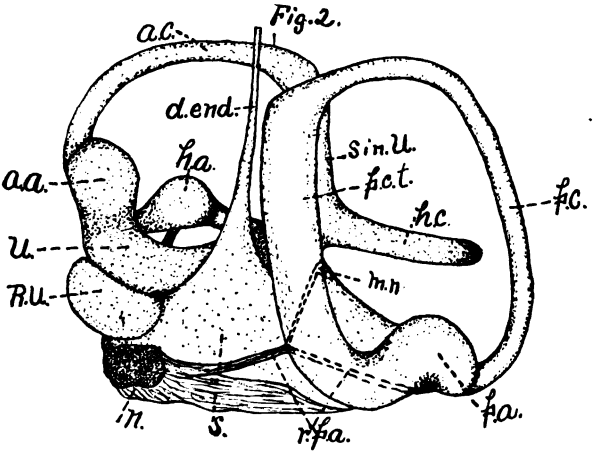

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PLATE XIII.

ILLUSTRATING THE PAPER OF WARREN H. EVERETT, p. 176.

FIG. 3. The membranous ear as seen from in front. It shows the overlapping of the connecting tube of the posterior canal (p. c. t.) over the sinus utriculus (sin. u.). It also shows the position of the nerve (n.) which supplies the recessus utriculus (r. u.) and the ampullæ of the horizontal and anterior canals (h. a.) (a. a.).

FIG. 4. The membranous ear as seen from behind. It shows the posterior canal (p. c.) and the tube (d. c. p.) that connects it with the sacculus (s.), lagena (l.) and sinus utriculus (sin. u.) as seen from a posterior direction. It shows the angle of the horizontal canal (h. c.) with respect to the body of the ear. Also a general end view of the sacculus (s.). It also shows the ampullar tube (a. t.) of the horizontal canal (h. c.).

FIG. 5. The membranous ear as seen from above. It shows the large curve made by the horizontal canal (h. c.) and the shape of the ampulla (h. a.) of the horizontal canal (h. c.) together with the angle at which it enters the utriculus (u.) at the base of the anterior ampulla (a. a.). The darkened line from the horizontal and anterior ampullæ represents the diagonal line of depression (* *) which marks the separation of the utriculus (u.) and sacculus (s.). This view also shows the angle between the posterior and anterior canals (p. c.), (a. c.).

FIG. 6. This is a drawing traced from a photograph of ear, eye and brain. It shows the angles made by the anterior and posterior canals with the axis of the head and with each other. Also the position of the ear as referred to the eye and brain.

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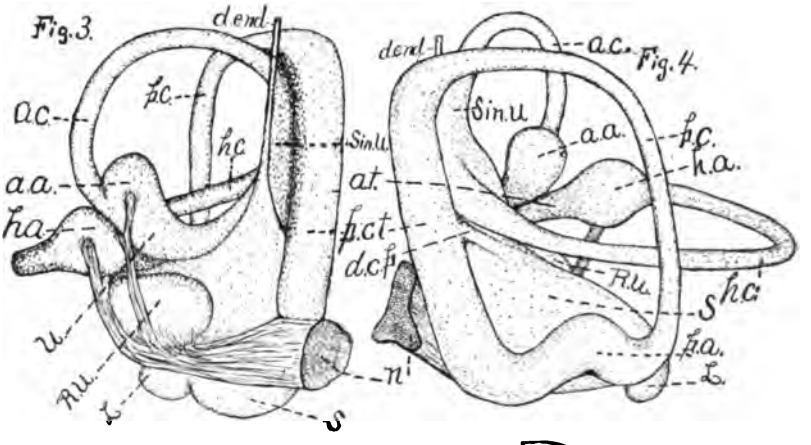

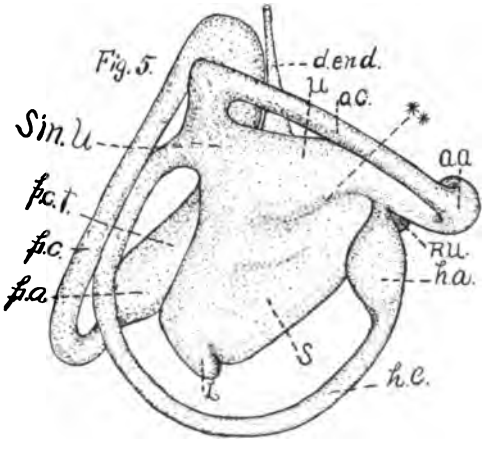

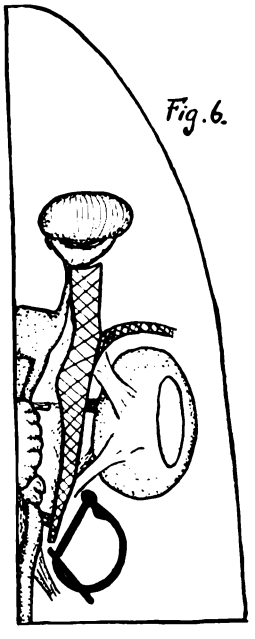

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PLATE XIV., CIRRIPEDIA, ETC.

Notation of the horizons, used below :

Div. $1c^1$. Horizon of Paradoxides lamellatus.
Div. $1c^2$. Horizon of Paradoxides Eteminicus.
Div. $1d^1$. Horison of Paradoxides Abenacus.
Div. $1d^2$. Horizon of Paradoxides Davidis.

FIG. 1. *Stenotheca concentrica.* Flattened and cracked along the back. Mag. $\frac{1}{1}$. From Div. $1\,d^1$, St. Martins, N. B. See p. 201.

FIG. 2. *S. concentrica* var. *radiata.* Mag. $\frac{1}{1}^0$. From Div. 1 *c*, St. John, N. B. See p. 202.

FIG. 3. *Stenotheca Hicksiana.* Mag. $\frac{1}{1}$. From Div. $1\,d^1$, St. Martin's, N. B. See p. 205.

FIG. 4. *Stenotheca triangularis. a,* a cast of, showing the outline of the cone and the thickened apex. *b,* a cast without the outline. Both mag. $\frac{1}{1}$. From Div. $1\,c^2$, St. John, N. B. See p. 203.

FIG. 5. *Strobilepis spinigera,* J. M. Clarke. Terminal plate (and penultimate plate in outline). Figured for comparison from Dr. Clarke's restoration. Mag. $\frac{3}{4}$. The terminal plate is partly covered by the penultimate. Devonian species. See p. 203.

FIG. 6. *Stenotheca nasuta. a,* small example, mag. $\frac{2}{1}$. *b,* original type mag. $\frac{1}{1}$. Both from Div. 1 *c*, St. John, N. B. See p. 204.

FIG. 7. *Plumulites Manuelensis,* n. sp, mag. $\frac{1}{1}$. From Div. $1\,d^2$, Manuel Brook, Newfoundland. See p. 200. (Misprinted Plate XV. on p. 200.)

FIG. 8. Cirripedian and other plates. Type A, *a* and *b*, two forms of oval plates. Type B, *a*, ribbed plate ; *b*, smooth plate. Type C, *a*, plate with deep furrow ; *b*, plate with high umbo; *c*, plate with eared flange ; *d*, plate similarly flanged but more regular ; these are perhaps Cystidian. Type D, symmetrical plate, perhaps one of the axial row of plates. Type E, triangular plate with radiating ridges (possibly cystidian). Type F, triangular plate with arched keel (*Cirropodites Cambrensis*). Type G, triangular plate with facetted edges. All the figures except 8 G, a, mag. $\frac{2}{1}$ 8 G, a, is mag. $\frac{1}{1}$. The narrow figures beside the larger ones are sections. See p. 206.

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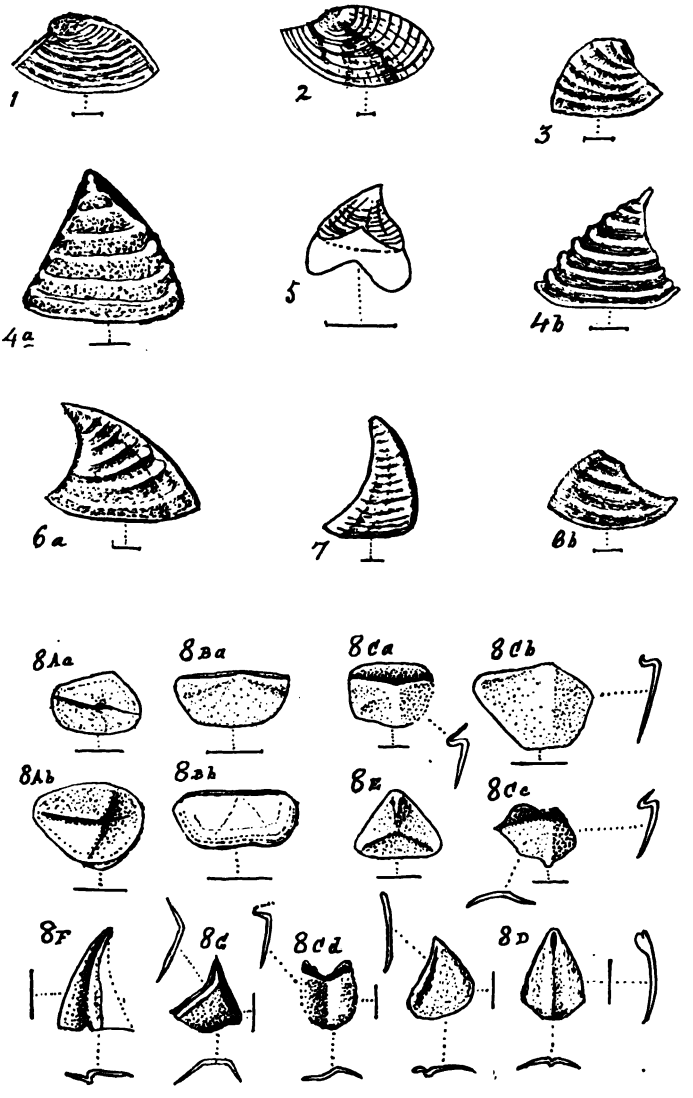

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PLATE XVI., AGNOSTUS.

FIG. 1. *Agnostus regulus.* *a*, head shield. *b*, a joint of the thorax. *c*, Pygidium. Mag. $\frac{4}{1}$. From Div. 1 c^2. See p. 213.

FIG. 2. *Agnostus rex* Barr. var. *transectus* n. var. Pygidium, Mag. $\frac{4}{1}$. From Div. 1 d^1, St. Martin's. See p. 214.

FIG. 3. *Agnostus parvifrons* Linrs. var. *tessella.* *a*, head shield. *b*, thorax. *c*, pygidium, Mag. $\frac{4}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 221.

FIG. 4. *Agnostus umbo.* *a*, head shield. *b*, pygidium. Mag., $\frac{4}{1}$. From Div. 1 d^1, St. Martin's N. B. See p. 222.

FIG. 5. *Agnostus obtusilobus.* Mag. $\frac{4}{1}$. From Div. 1 d^1. St. Martin's N. B. See p. 223.

FIG. 6. *Agnostus Davidis*, Hicks. Pygidium. Mag. $\frac{4}{1}$. From Div. 1 d^2, Manuel Brook, Newfoundland. See p. 225.

FIG. 7. *Agnostus gibbus*, Linrs. var. *partitus.* Head shield. Mag. $\frac{4}{1}$. From Div. 1 c^2, St. Martin's, N. B. See p. 227.

FIG. 8. *A. gibbus* var. *acutilobus.* Mag. $\frac{4}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 227.

FIG. 9. *Agnostus Nathorsti*, Brögg, var. *confluens*, n. var. *a*, head shield. *b*, pygidium. Mag. $\frac{4}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 230.

FIG. 10. *Agnostus fissus*, Lundgr. var. *trifissus*, n. var. Mag. $\frac{4}{1}$. From Div. 1 d^1, St. Martin's, N. B. See p. 231.

FIG. 11. *Agnostus punctuosus*, Ang. *a*, head shield. *b*, pygidium. Mag. $\frac{4}{1}$. From Div. 1 d^2, Highland Cove, Newfoundland. See p. 232.

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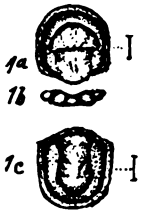

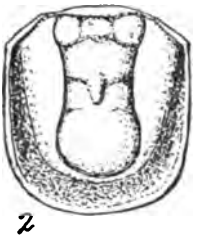

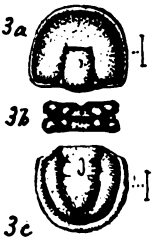

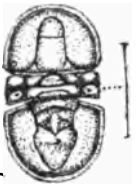

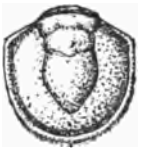

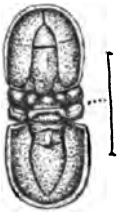

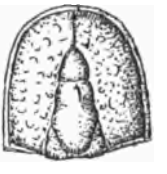

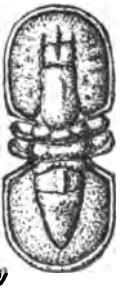

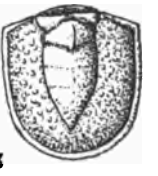

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PLATE XVII., AGNOSTUS AND MICRODISCUS.

FIG. 1. *Agnostus lævigatus*, Dalm., var. *terranovicus*, n. var. *a*, head shield. *b*, pygidium. Mag. $\frac{4}{1}$. From Div. 1 d^2, Highland Cove, Newfoundland. See p. 233.

FIG. 2. *A. lævigatus* var. *mammilla*, n. var. *a*, head shield. *b*, pygidium. Mag. $\frac{4}{1}$. From Div. 1 d^2, Highland Cove, Newfoundland. See p. 235.

FIG. 3. *A. lævigatus* var. *ciceroides*, n. var. *a*, head shield. *b*, pygidium. Mag. $\frac{4}{1}$. Found with the preceding. See p 234.

FIG. 4. *Microdiscus Schucherti* n. sp. *a*, head shield. *b*, pygidium. Mag. $\frac{4}{1}$. From Olenellus limestone, Troy, N. Y. See p. 238.

FIG. 5. *Microdiscus Dawsoni*, Hartt. *a*, head shield. *b*, same in profile. *c*, pygidium. Mag. $\frac{4}{1}$. *d*, young larval stage, head shield. Mag. $\frac{10}{1}$. *e*, next larval stage, head shield. Mag. $\frac{10}{1}$. All from Div. 1 c^1, St. John, N. B. See p. 240.

FIG. 6. *Microdiscus speciosus*, Ford. head shield. Mag. $\frac{4}{1}$. From Olenellus limestone, Troy, N. Y., figured for comparison. See p. 236.

FIG. 7. *Microdiscus precursor*. Head shield. Mag. $\frac{4}{1}$. From Div. 1 c^2, St. Martin's, N. B. See p. 239.

FIG. 8. *Microdiscus pulchellus* Hartt. *a*, head shield. *b*, same in profile. *c*, pygidium. Mag. $\frac{4}{1}$. *d*, embryonic or Protaspis stage. Mag. $\frac{20}{1}$. *e*, early larval stage. *f*, pygidium of same. Both Mag. $\frac{20}{1}$. All from Div. 1d^1, St. Martin's, N. B. See p. 242.

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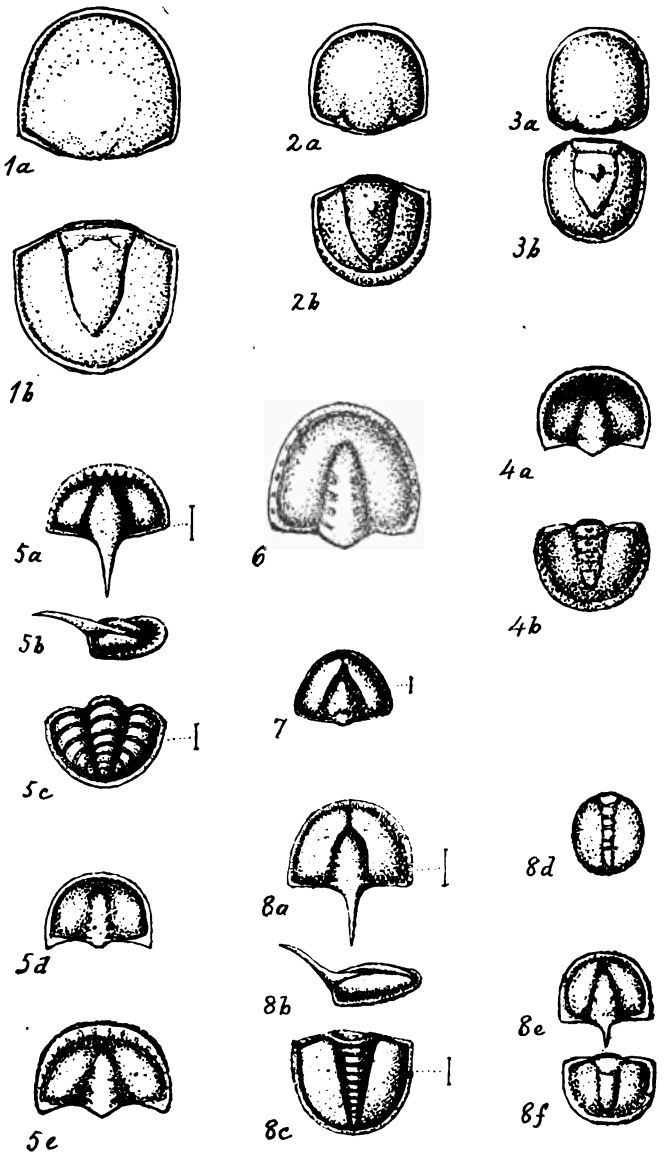

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Explanation of Plate.

Plate XVIII. Geological Maps of the Region about Brown's Park, Utah. The geography is based on the map by C. A. White, in the Ninth Annual Report of the Director of the U. S. Geological Survey.

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NEW YORK

ACADEMY OF SCIENCES

Third Annual Reception

and **Exhibit** of

Recent Progress in Science

in the

American Museum of Natural History

March 26th

1896

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New York Academy of Sciences.

FOUNDED IN 1817.

ORGANIZATION.

The Academy is fourth in point of age among the American scientific societies. It was organized in 1817 as the Lyceum of Natural History, and the present title was adopted in 1876. The constitution and organization are designed to make the Academy broadly representative of Science. The meetings and publications of the Academy are therefore open to all departments of scientific research.

The former Presidents have been: Dr. Samuel L. Mitchill, 1817–1823. Professor John Torrey, 1824–1826; 1836. Major Joseph Delafield, 1827–1837; 1839–1865. Professor Charles A. Joy, 1866–1867. Professor John S. Newberry, 1868–1892. Professor O. B. Hubbard, 1892–1893. Dr. H. Carrington Bolton, 1893–1894. Professor John K. Rees, 1894–1896.

MEMBERSHIP.

Honorary Members are limited to fifty in number, and are elected from the representative scientific men of the world. Corresponding Members are also chosen from distinguished men in different parts of the world who engage in the prosecution of some branch of research, the results of which they are expected to communicate to the Academy from time to time. This list now includes over 300 names.

Fellows are chosen from among the Resident Members, in recognition of scientific attainments or services; they form the Council and the main working body, and conduct the business of the Academy.

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Resident Membership is not restricted to specialists, but is open to those who take a general interest in science and desire to promote the work of the Academy by their subscriptions.

The Initiation Fee is $5, and the annual dues are $10. Payment of these confers upon Members full privileges and the right to all publications. By payment of $100 a Member may become a Life Member, commuting his annual dues. Donors of $250 become Patrons, and have all the privileges of Life or Resident Members.

Resident and Corresponding Members are elected as follows: The candidates are proposed publicly, in writing, at any meeting, by a Fellow or Member; and the nominations, together with the name of the person making them, are referred to the Council; if approved, the candidates may be elected by ballot at any succeeding business meeting.

PUBLICATIONS.

The publications of the Academy at present consist of three series—*The Annals*, *The Transactions* and *The Memoirs*. Both are distributed to Members and Fellows, and are circulated in exchange for the publications of nearly all the foreign Academies and learned Societies. The Annals opened in 1824 and are now in the ninth volume of the second series; altogether nineteen volumes have been issued. They contain the longer contributions and reports of researches, and have given world-wide reputation to the Academy. The Transactions were begun in 1881; they contain a record of the meetings, including abstracts of the shorter papers, and are now in the thirtieth volume. The Transactions appear regularly in signatures, or are sent in complete octavo volumes at the end of the year, according to the wishes of Members. Under the present system of printing, an author can secure immediate publication and distribution of a discovery in which it is important to establish priority. The present edition of both the Annals and Transactions is 1000. The Memoirs are issued in quarto form and are adapted to papers requiring large plates or tabulations. They were begun in the current year and one number has been already issued.

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LIBRARY.

The Library numbers over 18,000 titles, and is especially rich in sets of the publications of American and Foreign Societies. In this respect it is one of the most complete in this country. It is now shelved in a special room of the Library building at Columbia College, and is accessible to Members from 8 A. M. to 10 P. M., every day of the year.

MEETINGS.

The Academy at present enjoys the hospitality of Columbia College in the use of Hamilton Hall. There is, however, no official connection between the Academy and the College. Meetings are held every Monday at 8 P. M., from October to May inclusive. One evening of the month is given to a general business and scientific session. The other evenings are given to the Astronomical and Physical, Biological (Physiology, Zoölogy, Botany), Geological and Mineralogical sections. Other sections may be formed by a vote of the Council and one is now being organized in Philology and Philosophy. Each of the Sectional evenings is devoted mainly to respective papers and discussions. All the meetings are open to the public and are announced with the subjects of the papers to be read in the bulletins of the Scientific Alliance of New York.

POPULAR LECTURES.

The Academy is largely aided in its scientific work by its general membership, and the course of illustrated popular lectures arranged for each winter is specially for the benefit of the general Members and of the public. The subjects of the lectures are chosen from different branches of science, and are designed to present in a popular manner the latest results of research. Each member receives two Course tickets, and additional tickets can be procured. During the present year, 1895–6, the lectures are being delivered in the large lecture room of the Columbia Law School.

Persons desiring to join the Academy or support its scientific work by subscription should address,

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New York Academy of Science,
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(Organization not perfected before the Reception.)

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ASTRONOMY.

A

In Charge of Harold Jacoby.

1. Photographs Illustrating Objects Discovered at Harvard College Observatory. Exhibit of Harvard College Observatory, E. C. Pickering, Director.
   1. Harvard College Observatory, Cambridge Station.
   2. Arequipa Station, elevation 8,060 ft. El Misti in the background.
   3. Summit of El Misti, elevation 19,200 ft.
   4. Meteorograph on El Misti, records temperature, pressure, moisture, direction and velocity of wind for three months without winding.
   5. Bruce Photographic Telescope, aperture 24 inches.
   6. Removal of Bruce Telescope to Peru.
   7. Meteor trail. Arequipa, September 6, 1895.
   8. No. 7, enlarged 6 times.
   9. Portion of Moon.
   10. Jupiter, Saturn.
   11. Nebulosity surrounding η Carinæ, exposure 14 hours.
   12. Cluster ω Centauri, exposure 6 hours. Contains 30 variable stars.
   13. Cluster in Canes Venatici [N. G. C. 5272]. Contains 87 variable stars.
   14. Cluster in Serpens [N. G. C. 5904]. Contains 46 variable stars.
   15. Cluster in Serpens [N. G. C. 5904]. Taken two hours later than No. 14 and showing change in brightness of several of the stars.
   16. Cluster in Sagittarius [N. G. C. 6656]. Contains 4 variable stars.
   17. New Star in Perseus, 1887.
   18. New Star in Norma, 1893.
   19. New Star in Carina, 1895.

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20. New Star in Centaurus, 1895.
21. Spectra of Stars in vicinity of η Carinæ.
22. Spectra of Stars in cluster in Carina [N. G. C. 3532].
23. Discovery of new variable stars from their spectra.
24. New Algol variable in Delphinus.
25. Light curves of variable stars.

2. PHOTOGRAPHS of Planetary Spectra made with the Spectroscope of the Allegheny observatory. Exhibit of Prof. J. E. Keeler, Allegheny, Pa.

These photographs were made either for the purpose of determining the relative motion in the line of sight of different parts of the surface of a planet, or for determining whether it is possible to detect the existence of an atmosphere around a planet by absorption lines in its spectrum.

1. Spectrum of Jupiter, region of Hγ, October 16, 1892. No comparison spectrum.
2. Spectrum of Jupiter; region of yellow green, February 24, 1895. Sky spectrum for comparison. Original negative.

The obliquity of the planetary lines is due to the rotation of Jupiter.

3. Positive Copy of (2).
4. Spectrum of Jupiter; region of D, February 26, 1895. Sky spectrum for comparison.

This spectrum extends far *below* the principal water-vapor band δ, which, however, does not appear on the photograph, as the negative was developed for the D lines.

5. Spectrum of Saturn; focus on λ 5352. April 9, 1895. Lunar comparison spectrum. Original negative. First measurement of relative velocities in the system of Saturn. (*Astrophysical Journal*, May and June, 1895.)
6. Spectrum of Saturn, April 28, 1895. Positive copy.
7. Spectrum of Venus, April 23, 1895, with simultaneously photographed sky spectrum. The planetary lines are displaced slightly toward the violet by the approaching motion of Venus.

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8. Spectrum of Venus, with simultaneously photographed sky spectrum, November 12, 1895. This photograph was made with a diffraction grating (3d spectrum, $H\gamma$) and a camera of 28 in. focus, and shows the highest dispersion that it has been practicable to use so far. Made in connection with experiments, not yet completed, on the possibility of determining the rotation period of Venus by spectroscopic methods.
9. Solar Spectrum, same apparatus as for No. 8, showing the definition of the instrument under favorable circumstances.
10. Enlargement of Spectrum of Saturn, April 17, 1895.
11. Enlargement of Spectrum of Saturn, region of $H\gamma$, May 16, 1895. By Prof. W. W. Campbell, with the Lick Spectrograph. (*Astrophysical Journal*, August, 1895.)

3. Six-inch Equatorial Telescope. New Model.
4. Improved Filar Micrometer.
5. Photographs of Large Equatorials.

Nos. 3–5 exhibited by Messrs. Warner & Swasey, Cleveland, O.

6. Spectroscope to fit six-inch equatorial.
7. Very small Spectroscope.
8. Helioscope.
9. Telescope Objectives.
10. Accurate Plane and Parallel Surfaces.

No. 6–10 exhibited by J. A. Brashear, Allegheny, Pa.

11. Microscope Theodolite, by Wannschaff of Berlin, made 1895.
12. Lantern Slides from original negatives of the following objects:
    1. Eta Argus, from negatives made at the Cape of Good Hope Observatory by C. Ray Woods, under the direction of Dr. Gill. Exposure times vary from five minutes to twenty-five hours. For comparison, Herschel's drawing of 1834 will be shown.

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2. Variable star in Vela, several photographs, showing the variation of the star.
3. Specimen plates of the Astro-photographic Catalogue and Chart work at the Cape of Good Hope Observatory.

Nos. 11 and 12 exhibited by Columbia University Observatory, J. K. Rees, Director.

PHYSICS.

B

In Charge of William Hallock.

1. Dibdin Pentane Lamp. Exhibited by Alexander C. Humphreys. The Standard of illumination adopted in London. It is approximately equal to 10 candles.

2 Polariscope, special form designed by Prof. A. M. Mayer. Exhibited by the Department of Physics, of Columbia University.

3. Two Mirror Heliostat. Designed by Prof. A. M. Mayer. Exhibited by the Department of Physics, of Columbia University.

4. Apparatus for Showing the Vibration of a String. Designed by Prof. W. L. Robb. Exhibited by O. N. Rood.

5. Apparatus for Voice Analysis. A modification of the Kœnig apparatus, with photographic record. Accompanied by a set of corresponding organ-pipes.

6. Photographs of the same vowel in typical voices.

7. Photographs of different vowels in the same voice.

8. Apparatus for Photographing the Vocal Cords in Action. A combination of laryngoscopic mirror, special Camera and Shutter.

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9. PHOTOGRAPHS OF VOCAL CORDS IN ACTION ON DIFFERENT PITCHES. Showing the rotation of the aretynoid cartilages and consequent shortening of the vibrating length of the cords.

Nos. 5–9, exhibited by W. Hallock and F. S. Muckey.

10. RÖNTGEN PHOTOGRAPHS. Exhibited by W. L. Robb, W. W. Griscom and W. Le Conte Stevens.

11. RÖNTGEN PHOTOGRAPHS AND APPARATUS. Exhibited by O. N. Rood.

12. PSEUDO-RÖNTGEN PHOTOGRAPHS. Exhibited by H. S. Curtis. Made by sunlight through an ebonite slide.

13. MAHLER'S MODIFICATION of Berthelot's Calorimeter. Exhibited by J. Struthers.

14. THOMPSON'S CALORIMETER. Exhibited by J. Struthers.

15. LOVIBOND TINTOMETER. Exhibited by C. F. Chandler.

16. MICRO-STEROGRAPH. Exhibited by O. N. Rood. Taken by a special method.

17. MODIFICATION OF REGNAULT'S SPECIFIC HEAT APPARATUS. Exhibited by the Department of Physics, of Columbia University.

ELECTRICITY.

C

IN CHARGE OF M. I. PUPIN.

1. APPARATUS for studying long electric waves, and curves, plotted from experimental data, illustrating the distribution of long electric waves along a conductor. Exhibited by Prof. M. I. Pupin.

An alternating electric current is propagated along a long conducting line, say a telephone wire, by a series of progressive waves. The exhibit represents an artificial conductor of 500 miles in length corresponding to a long distance telephone line of the same length and the meas-

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urements obtained with it represent the first experimental data that have ever been obtained in this field of electric research.

2. APPARATUS for studying the magnetic lag in closed magnetic circuits and diagrams, plotted from experimental data, recording the results obtained. Exhibited by Chas. T. Rittenhouse, Fellow in Electricity, Columbia University.

When iron is magnetized by a rapidly varying force the magnetization does not keep in step with the force, but lags behind it. This lag is due to induced currents in the mass of the iron and to internal viscosity; it is especially strong in closed magnetic circuits, and increases with the increase of the speed of the magnetizing force, but diminishes with the increase of temperature.

3. APPARATUS employed for generating the radiant energy discovered by Professor Röntgen. Exhibited by Prof. M. I. Pupin.

A rotating current interruptor and induction coil and different types of Crooke's and electrodeless tubes.

4. SILHOUETTES or RADIOGRAPHS obtained by the Röntgen method. Exhibited by several physicists whose names are attached to the several exhibits.

CHEMISTRY.

D

IN CHARGE OF C. E. PELLEW AND MORRIS LOEB.

1. ARGON AND HELIUM. Exhibited by Charles E. Pellew and Samuel A. Tucker.

Argon and Helium are two newly discovered elements of the Nitrogen group. Argon occurs in minute particles in the atmosphere.

Helium was first discovered by the spectroscope, in the atmosphere of the sun, and more recently has been prepared in bulk from Monazite and other minerals.

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The exhibit shows tubes of Argon and Helium, rendered incandescent by the electric spark, so as to exhibit the characteristic spectra.

Also tubes containing large amounts of Helium, and the apparatus for preparing Helium from Monazite.

2. NORMAN HEPTYL SULFOCYANIDE. Exhibited by Marston T. Bogert, of the Department of Organic Chemistry, School of Mines, Columbia University.

This compound, hitherto unknown, was prepared by the exhibitor in January, 1896. Its graphic formula is:

$CH_3.\ (CH_2)_6.\ SCN.$
Sp. Gr. = 0.931 @ 15° C.
B. P. = 230–234° C.

When freshly distilled, it forms a colorless oil, which gradually turns yellow when exposed to light and air.

PHOTOGRAPHY.

E

IN CHARGE OF CORNELIUS VAN BRUNT.

1. ANTI-HALO, for preventing halation, with plate coated and plates showing the difference.
2. META-CARBOL, a new developing material, with bottle of developer and negatives.
3. STIPPLE PLATES, the use of which will prevent retouching. These are to be used in contact with the plates during exposure in the camera, with prints illustrating the same.
4. OLMSTED'S LANTERN SLIDE MATS, from which any design or size of Mat can be cut without the aid of a ruler.
5. WYNNE'S EXPOSURE METER, a pocket apparatus for giving the correct time of exposure.

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6. DALMEYER BERGHEIM PORTRAIT LENSE.

7. DALMEYER STIGMATIC LENSE.

Nos. 1–7 exhibited by E. and H. T. Anthony.

8. NEW PHOTOGRAPHIC APPARATUS. Exhibited by Scoville & Adams Co.

9. HIGH-CLASS and NOVEL "PROJECTION APPARATUS." Exhibited by J. B. Colt & Co.

10. NEW LANTERNS and APPARATUS. Exhibited by Charles Beseler.

11. SAMPLES OF ARTOTYPE, in color.

12. SAMPLES OF FACSIMILE.

Nos. 11 and 12 exhibited by Edward Bierstadt.

13. PHOTO-MICROGRAPHS, in three colors. Exhibited by Edw. Leaming, M. D.

14. 24 PHOTOGRAPHS OF "LIGHTNING." Exhibited by W. N. Jennings.

1. First photograph of lightning ever taken, to prove that the discharge is *wavy*, not *zigzag*, as usually represented by artists. Taken September 2, 1882, at Philadelphia.
2. Photograph clearly demonstrating the truth of the "wavy line" theory of lightning.
3. Artificial lightning (Holtz machine discharged) for comparison with real "Jersey Lightning."
4. Divided discharge (forked lightning).
5. "Branched" lightning, explaining "tree marks" often found upon the bodies of persons struck by lightning.
6. Artificial "branched" discharge (the spark from a Holtz machine flashed directly across the face of the photographic plate, no lens being employed).
7. Parallel discharges. Stratification due to movement of conducting path by the wind.

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8. Holtz machine "Brush" discharge (Photographic plate being placed horizontally between the electrodes), showing *electric* "lines of force."
9. Holtzmachine spark (plate being placed vertically between the electrodes), showing *electric* "lines of force."
10. Meandering discharge. Illustrating the service of trees during a thunder storm—to dissipate, neutralize or conduct the discharge.
11. "Beaded" or "Rosary" lightning. Supposed to be the track of a rotating ball of fire moving through space. A "thunderbolt."
12. "Beaded" or "Rosary" lightning.
13. Two parallel discharges branching from a main stem.
14. Radial lightning. The discharge having the appearance of heat-cracked glass.
15. Collision of two discharges in mid-air, and the production of "thunderbolts."
16. "Ribbon" lightning. (An oscillating discharge moved by the wind.) Caught on the prairie of North Dakota at midnight from the rear platform of an express train.

15. REPRODUCTION OF THE THREE COLOR PROCESS. Negatives and plates untouched by hand. Examples are from Life, Nature, Still Life, Paintings, produced by the N. Y. Photogravure Company. Exhibited by Ernest Edwards.

16. RADIOGRAPHS WITH "ROENTGEN" RAYS, and other photographs. Exhibited by John S. McKay.
    1. Photographs of Apparatus used in producing Röntgen rays.
    2. Radiographs of hand containing bullet. Frog with broken leg. Bird with shot in body.
    3. Radiographs showing skeletons of small animals. Frog, turtle, salamander, etc.
    4. Radiographs showing relative capacity to "Röntgen rays" of various solids and liquids.

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5. Electrographs of Coins taken in the dialectric of a condensor.
6. Photograph of bottom of developing tray broken in a dark room, upon plates which had been exposed to "Röntgen" rays.
7. Radiographs of a Key taken at more than six feet from vacuum tube.

17. ARC LAMP FOR PHOTOGRAPHY, which operates under conditions of absolute steadiness for all photographic purposes.

18. SCREEN FOR DIFFUSING LIGHT, assuming many different shapes by a touch.

Nos. 17 and 18 exhibited by the International Lamp Co.

GEOLOGY.

F

IN CHARGE OF J. J. STEVENSON.

1. Suite of ORES, ROCKS and PHOTOGRAPHS from Cripple Creek, Colorado. Exhibited by Prof. J. F. Kemp. The ore deposits are oftenest associated with dikes of phonolite or nepheline-basalt that penetrate the red granite of the Pike's Peak region, or a decomposed breccia of andesite. They also line in veins which fill more or less irregular fissures in the andesite breccia away from dikes. The ores are fresh or decomposed telluride of gold.

This district was described before the Academy, February 7, 1896.

2. Suite of ORES, ROCKS and PHOTOGRAPHS from the Bertha and Wythe Zinc mines, in southwest Virginia. Exhibited by Prof. J. F. Kemp. The Siluro-Cambrian limestone has been originally charged with zinc blende and pyrites at the Bertha mines, and with these and galena at the Wythe mines. It has decomposed, leaving a residual

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clay. The zinc blend has yielded calamine, a hydrated silicate of zinc, that has leached down and formed incrustations on the undecomposed limestone.

These mines were described to the Academy November 18, 1895.

3. Suite of SPECIMENS from Essex County, N. Y., showing the development of crushed and brecciated rocks and gneisses from originally massive igneous forms. Exhibited by Prof. J. F. Kemp. The specimens are the labradorite rock and gabbros from the Adirondacks. No. 1 shows a massive, coarsely crystalline aggregate of dark crystals of labradorite from Lake Sanford; in No. 2 and following numbers the minerals are more and more crushed until only a pulp of the original rock is left in No. 13. Nos. 14–19 show the development of gneissoid forms; Nos. 20 and following exhibit the passage of massive gabbro into hornblende gneiss. The changes were brought about by dynamic metamorphism.

4. Series of ROCK SPECIMENS, MAPS and PHOTOGRAPHS illustrating the geology of Mount Desert Island, Maine, and vicinity. Exhibited by Theodore G. White, Geological Department, Columbia University.

This embraces the original metamorphosed, unfossiliferous slates, through which the following rocks were ejected: The red granite, forming the central core of the island; rhyolites, varying in type and structure; representatives of a few of the dikes; ores and associated rocks from the Blue Hill and Cape Rosier, Maine, copper mines; contorted quartzose schists from Blue Hill.

5. Set of ROCKS from the southern portion of the Boston Basin, Mass., collected by Prof. W. O. Crosby. Exhibited by Theodore G. White.

This series embraces the *Paradoxides* slates of Braintree; the Quincy hornblendic granite; biotitic granite; diorites and dioritic granites; flow and porphyritic

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rhyolites of the Blue Hills and their gradations; the melaphyr outflow and accompanying conglomerates of Hough's Neck; selections from the dikes.

6. Series of SPECIMENS from Montreal, Canada. Collected and exhibited by Theodore G. White.
   1. Mile-End quarries; Trenton and Chazy limestone.
   2. Corporation quarries; elæolite syenite and associated limestone, slates, granites and dikes. The elæolite syenite here cuts the Trenton limestone and is older than the Helderberg, because boulders of it are found in the Helderberg conglomerate.

7. BAUXITE and ASSOCIATED CLAYS from northwestern Georgia and northeastern Alabama with photographs of the mines. Exhibited by Heinrich Ries.

   This material, which is used for the manufacture of alum and aluminum, occurs in a belt about 40 miles long. Its formation is due to the action of hot springs.

8. DIKES from Dorset Mt., Vt. Exhibited by Heinrich Ries. These dikes are found in the marble quarries at several points.

9. VARIEGATED MARBLES from Swanton, Vt. Exhibited by Heinrich Ries.

10. A series of GNEISSIC ROCKS and DIKES from the Highlands of Orange Co., N. Y. Exhibited by Heinrich Ries.

    The Highlands of Orange Co., N. Y., are composed of a series of gneisses and gneissic rocks with occasional interbedded limestones and deposits of magnetite. These rocks are cut by many dikes of diabase and diorite. They will be described in the report of the State Geologist for 1895.

11. KAOLINS from North Carolina, collected by J. A. Holmes. Exhibited by Heinrich Ries.

12. PORPHYRITIC GNEISS and INTRUSIVE ROCKS of the Cortlandt series from Bedford village, Westchester Co., N. Y. Exhibited by L. M. Luquer and Heinrich Ries.

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This peculiar phase is marked with the development of phenocrysts of feldspar. They were furthermore penetrated by gabbroitic rocks. These latter represent a new and undescribed extension of the Cortlandt series to the eastward.

13. SERIES of COALS from Madrid, New Mexico. Exhibited by Prof. J. J. Stevenson.

    These are from the Old Placer coal field and show the passage from bituminous to anthracite coal.

14. Specimens of ASPHALT from Indian Territory. Exhibited by Prof. J. J. Stevenson.

    This material is obtained from the Upper Carboniferous beds of south-central Indian Territory.

15. A series of LEAD and ZINC ORES from Joplin, Mo. Exhibited by Prof. J. J. Stevenson.

16. A series of ROCK SALT SPECIMENS, collected from central New York by C. Q. Freeman. Exhibited by Prof. J. J. Stevenson.

MINERALOGY.

G

IN CHARGE OF EDMUND OTIS HOVEY.

1. LORANDITE, with REALGAR, Macedonia. A compound of Tl, As and S, a new mineral.

2. OLIVENITE, Centennial Mine, Tintic Dist., Utah. Very fine crystals.

3. SYLVANITE, Cripple Creek, Colorado.

4. GRIPHITE, Riverton Lode, near Harney City, S. D. A rare, problematical phosphate of Al, Mn, Ca, Na, etc.

5. ARGYROPYRITE and PYRARGYRITE, Freiberg, Saxony.

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6. LITHIOPHORITE, Rengersdorf, Germany. A manganese ore containing lithium.

7. POWELLITE, Calumet, Mich. A new locality for this rare mineral.

8. AEGIRITE, Langesund, Norway. A fine, large crystal.

9. EPISTILBITE, Bernfiord, Iceland.

10. OPAL, Frankenstein, Silesia. Green.

11. CASSITERITE, Lake Titicaca, Bolivia.

12. KYLINDRITE, Santa Cruz Mine, Poopé, Bolivia. $Pb_6Sb_2Sn_6S_2$. A new mineral.

13. SULPHUR, Japan. Contains tellurium.

14. BARITE, Silver Plume, Colorado. A large crystal.

15. BARIUM-FELDSPAR, Grythyltan, Sweden.

16. ASBEFERRITE, Grythyltan, Sweden. An iron-manganese amphibole.

17. GANOMALITE, Nordmarken, Sweden. A rare silicate of lead, calcium and manganese.

18. MANGANHISINGERITE, Silfberg, Sweden.

19. MANGANAPATITE, Horrsjoberg, Sweden.

20. MANGANBRUCITE, Nordmarken, Sweden.

21. MANGANOSTIBIITE.

22. BIHARITE, Rezbánya.

23. CARPHOSIDERITE, Romanche, France.

24. VESZELYITE, Vaseo.

25. WAD, Romanche, France. Var. *Groroilite.*

26. MUSCOVITE, Lincoln Co., N. C. Transparent green crys tals.

27. APOPHYLLITE, Paterson, N. J.

28. ZIRCON, Ceylon. Cut gems.

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29. ANDALUSITE, Brazil. Cut gem.

30. RUBY, Paris, France. Artificial production.

31. WHEWELLITE, Zwickau, Saxony.

32. THAUMASITE, Areskutå, Sweden. From the original locality. Compare with that from West Paterson, N. J., recently discovered.

33. CALCITE, Richelsdorf, Hesse. Calc-sinter colored by cobalt.

34. CALCITE, Richelsdorf, Hesse. Calc-sinter colored by copper.

35. CROCIDOLITE, Cochabamba, Bolivia. New locality.

36. GOLD, Verespatak, Hungary.

37. PHOSGENITE, Monte Poni, Sardinia. On galenite.

38. MELANOPHLOGITE, Ragalmuto, Sicily. On sulphur.

39. LAUTITE, Nr. Marienberg, Saxony. With arsenic.

40. PHOLERITE, Kohlendorf, Sweden. A form of kaolinite. With millerite.

41. GALENOBISMUTITE, Falun, Sweden. Contains selenium.

42. TELLURIUM, Nagyág, Transylvania. With nagyagite.

43. TALC, Thiersheim, Bavaria. Pseudomorph after quartz.

44. TALC, Thiersheim, Bavaria. Pseudomorph after dolomite. A collection illustrating the association of minerals in the pegmatite veins near Bedford, N. Y.

45. URANINITE and URANOTILE.

46. AUTUNITE.

47. MENACCANITE (ILMENITE).

48. TOURMALINE.

49. GARNET.

50. QUARTZ, *a*, White.

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51. *b*, Rose.

52. *c*, Smoky.

53. FELDSPAR.

54. FELDSPAR and QUARTZ intergrowth forming "Graphic granite."

55. FELDSPAR "augen" in gneiss.

56. MUSCOVITE.

57. BIOTITE.

Nos. 1 to 57 exhibited by the Mineralogical Department of Columbia University, through Prof. Thomas Egleston and Dr. Lea McI. Luquer.

58. ORTHOCLASE, very large crystals, with specimens of associated minerals from veins of coarse pegmatite on the north shore of Long Island Sound.

Collected (1895) and exhibited by Prof. J. F. Kemp, Columbia University.

59. TOURMALINE. Bethel, Conn. A very large crystal. Exhibited by Prof. E. S. Dana, Yale University.

60. FEDOROW UNIVERSAL MICROSCOPE STAGE, combined with the KLEIN "UNIVERSAL-DREHAPPARAT;" made by R. Fuess in Berlin after the plans of Prof. E. von Fedorow, of Moscow, and Prof. C. Klein, of Berlin.

This apparatus, if placed on the stage of a polarizing microscope, allows the object, whether a thin section of a rock or mineral or a small crystal, to be placed at almost any angle to the axis of the microscope, for by means of the two axes of revolution, in addition to the usual horizontal revolution of the stage of the microscope about the axis of the instrument, we are able to revolve the object about three axes at right angles to each other, and hence bring almost any direction in it parallel to the axis of the microscope, subject of course to the necessary limitations to the extent of the motion which the condi-

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tions impose. This is especially useful in studying the optical properties of minerals in thin sections, as illustrated by the present arrangement of the instrument and the first cut accompanying it.

The other part, the "Universal Drehapparat," consists of a small glass vessel for holding a highly refracting fluid in which the section or crystal is immersed after being fastened on a small movable holder which permits adjustment to the axes of revolution of the apparatus. The microscope is placed horizontally, as shown in the second cut, and the observations made with the same possibility of revolution on three axes, whether for optical study or the measurement of the angles of crystals. A special long focus condensing lens and similar objective accompany the instrument, which allow space for the revolution of the object.

Exhibited by the Department of Mineralogy and Petrography of Harvard University through Prof. J. E. Wolff.

62. DANBURITE, Russell, N. Y. Twelve specimens showing the variation in form.

63. TOURMALINE, *a*, white, DeKalb, N. Y.

64. *b*, yellow, DeKalb, N. Y.

65. *c*, brown, Gouverneur, N. Y.

66. *d*, black, Pierrepont, N. Y.

67. WERNERITE, Pierrepont, N. Y.

68. WERNERITE, Bedford, Ontario.

69. WERNERITE, Burgess, Ontario.

70. APATITE, Burgess, Ontario.

71. APATITE, Eganville, Ontario.

72. APATITE, Bedford, Ontario.

73. TREMOLITE, Gouverneur, N. Y.

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74. HORNBLENDE, Russell, N. Y.

Nos. 62 to 74, fifty specimens, exhibited by Prof. A. H. Chester, Rutgers College.

75. PYROXENE, Tilly Foster mine, Brewster's, N. Y. A new form and very large for this locality.

76. CARBIDE OF ALUMINUM, crystals formed in an electrical furnace.

Nos. 75–76, exhibited by Heinrich Ries.

77. THE PHOSPHORESCENCE OF THE DIAMOND. Apparatus designed to show this peculiar feature of some stones by electric arc light. The phenomenon is thought to be due to the presence of a new hydrocarbon compound to which the name *tiffanyite* has been given. A phosphorescent liquid is introduced for comparison, and some non-phosphorescent diamonds for contrast. Exhibited by George F. Kunz.

78. APOPHYLLITE, Bernfiord, Iceland. Crystals showing the planes, *001*, *100*, *310*, *111*, *112*.

79. HEULANDITE, Bernfiord, Iceland. Crystals showing *010*, *001*, *110*, *201*, $\bar{2}01$, *021*, $\bar{1}11$.

80. STILBITE, Bernfiord, Iceland.

81. MUSCOVITE. Henry Lincoln Co., N. C. Crystals.

82. PHENACITE, Mt. Antero, Colorado. Twinned crystals.

83. PHENACITE, Mt. Antero, Colorado. Shows basal plane.

84. CHABAZITE, West Paterson, N. J. Shows basal plane.

Nos. 78 to 84 exhibited by Lazard Cahn.

Specimens from a new locality at West Paterson, N. J.:

85. HEULANDITE and APOPHYLLITE, two specimens belonging together.

86. HEULANDITE, large aggregation in the form of a geode.

87. HEULANDITE and CHABAZITE.

88. HEULANDITE, red and white in one aggregation.

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89. HEULANDITE, individual crystals.
90. HEULANDITE, *a*, green.
91. *b*, white.
92. *c*, red.
93. ANALCITE on PECTOLITE.
94. APOPHYLLITE, large group of primitive crystals.
95. APOPHYLLITE, primitive crystals.
96. APOPHYLLITE, two large modified crystals.
97. CALCITE, twin showing an etched face.
98. CALCITE, cleavage piece.
99. CHABAZITE, *a*, brown.
100. *b*, white.
101. *c*, green.
102. *d*, red.
193. DATOLITE with PREHNITE.
104. LAUMONTITE.
105. LAUMONTITE with twinned calcite.
106. PREHNITE, distinct crystals, very rare.
107. PECTOLITE.
108. PECTOLITE, sections of a sphere coated and cemented with calcite and quartz.
109. PECTOLITE.
110. QUARTZ, pseudomorph after pectolite, showing moulds of natrolite crystals.
111. NATROLITE.
112. STILBITE.
113. STILBITE, *a*, individual crystals.
114. *b*, sheaf-like form of aggregation.

Nos. 85 to 114 exhibited by A. H. Ehrman, Brooklyn.

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115. CYANITE, Death Rapids, Columbia River, British Columbia. Extraordinarily large blades in schist. Collected (1895) and exhibited by Frank L. Nason, New Brunswick, N. J.

116. HANKSITE, Borax Lake, California. A large cluster.

117. BORNITE, North Carolina.

118. QUARTZ, Organ Mountains, N. M. Shows phantom.

119. CALCITE, Burnet, Texas. Shows phantom.

120. LIGNITE, New Jersey. Contains siliceous casts of *Teredo navalis*.

121. BARITE, New Brunswick, N. J. Orange colored crystals.

122. PYRITE BALLS, South River, N. J.

Nos. 116 to 122 exhibited by John A. Manley, New Brunswick, N. J.

123. TOURMALINE, 171st street and Ft. Washington avenue, New York City. An unusually large crystal in its matrix.

124. XENOTIME, same locality. Three very large crystals in the matrix.

125. MONAZITE, same locality. A large crystal in its matrix and a detached group.

126. XENOTIME, 184th street and Harlem River Speedway, New York City.

127. AZURITE, Bisbee, Ariz.

128. STALAGMITE, Bisbee, Ariz. From the famous cave in the Copper Queen mine.

129. STALAGMITE, Bisbee, Ariz. Cut section, polished.

130. HELICTITES, Bisbee, Ariz. Strangely curved stalactites.

131. QUARTZ, Madrone, Santa Clara county, Cal. Two coatings of iridescent, drusy crystals.

Nos. 123 to 131, exhibited by the Department of Geology, Amer. Mus. Nat. Hist.

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132. THAUMASITE, West Paterson, N. J. Described from this locality in the *American Journal of Science* for March, 1896, by S. L. Penfield and J. H. Pratt.

133. LORANDITE, Macedonia. A new thallium mineral.

134. TOURMALINE, Connecticut.
From recent finds in southwestern Missouri.

135. GALENITE, CALCITE and SPHALERITE, Joplin.

136. SPHALERITE, Carterville. Very light colored. Iridescent.

137. LEADHILLITE and CALAMINE, Granby.

138. CALAMINE, Aurora.

139. MARCASITE, Aurora. Stalactites of fantastic form.
Nos. 132 to 139 exhibited by Geo. L. English & Co.

140. LAWSONITE, Tiburon Peninsula, Marin Co., Cal. A newly described silicate of Ca and Al. Three groups of orthorhombic crystals showing variety of habit. *Vid.* Am. Jour. Sci., July, 1895.

141. NORTHUPITE, Borax Lake, California. A newly discovered chloro-carbonate of Na and Mg. Eight octohedral crystals exhibiting variety of marking and grouping. Described by W. M. Foote, in Am. Jour. Sci., December, 1895.

142. OPALIZED WOOD, Idaho. A recent discovery of material remarkable for the perfection with which all the structural peculiarities of the wood have been preserved. Six sections, three of which have been polished.

143. LEADHILLITE, Granby, Missouri. Three pseudomorphs after galenite and calcite.

144. CALCITE. Amethystine Iceland spar showing bands of included marcasite crystals.

145. CHALCOPYRITE, southwest Missouri. On dolomite (pearl spar).

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146. RUTILE in QUARTZ, San Francisco Riv., Brazil. "Flèches d' amour." Very fine.

147. SPHÆROSTILBITE, Oregon.

148. CHABAZITE, Oregon.

149. THOMPSONITE, Oregon.

150. HALITE, Nr. Borax Lake, Calfornia. A suite of twelve transparent cubo-octahedral crystals.

151. HALITE, Nr. Borax Lake, California. Two groups of pale yellow and pink cubic crystals showing peculiar cavernous faces.

152. THENARDITE, Nr. Borax Lake, California. Two groups of unusually large crystals.

152. HANKSITE, Nr. Borax Lake, California. Group of very large, brilliant crystals.

154. DYSANALYTE, brilliant black crystals in gangue.

155. OPAL, Washington State. Green mottled with red. Three specimens, one of which is polished; from a new locality.

156. ENDLICHITE, Lake Valley, New Mexico. A rare variety of vanadinite in which arsenic has replaced half of the vanadium.

Nos. 140 to 156, forty-eight specimens, exhibited by Dr. A. E. Foote (W. M. Foote, Mngr.), Philadelphia.

156. TURQUOISE, Cerro de Potosi, Bolivia. Three pseudomorphs after orthoclase, simple and twinned.

158. PYRITE, Cerro de Potosi, Bolivia. Two pseudomorphs after orthoclase.

Nos. 157, 158 exhibited by Frederick A. Canfield, Dover, N. J.

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PHYSIOGRAPHY.

H

In Charge of R. E. Dodge.

1. A collection of the best and more recent scientific school and college text-books on the subject of Physiography. Loaned by the publishers.
2. A collection of relief models loaned by E. E. Howell, maker, Washington, D. C.
   - *a*. Topographical model of the United States and adjacent ocean bottoms, showing curvature of the earth.
   - *b*. The same showing influence of physical features of the United States on the distribution of rainfall.
   - *c*. Topographic model of the State of Connecticut.
   - *d*. Topographic model of New Jersey.
   - *e*. The same colored to show the relation of the geology to the physical features.
   - *f*. Topographic model of the vicinity of Chattanooga, Tenn.
   - *g*. The same to show the relation of geology to physical features.
3. A collection of illustrative models for use in teaching.
   - *a*. Three models showing stages of development of topography in the down cutting of streams on a coastal plain.
   - *b*. Two models showing effects of depression and elevation upon a land well worn down previously.
   - *c*. Three models showing development of form and drainage in a region made by faulting, as in lava blocks of Oregon.
   - *d*. Two models showing effect upon topography and drainage of the oncoming of a glacier.
   - *e*. Six models showing development of topography and drainage in a land made by volcanic action and

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then worn down after the volcanoes have become extinct.

f. Six models, in pairs, showing the interaction of neighboring streams in wearing down a region. Note adjustment of drainage to structure of rocks.

g. Three models showing formation of alluvial plain, the later conversion into a terraced valley and final removal of all loose material in the valley.

Exhibited by the Geological Department of Harvard University, through Prof. W. M. Davis, Chairman.

4. MAPS.

a. Geological map of State of Alabama, showing relation of lands worn down in Cretaceous times to the surrounding unconformable Cretaceous sediments.

b. Map of the alluvial plain of the Mississippi showing many features typical of rivers in their old age. Note position of stream in the flood plain.

c. Relief map of New Jersey showing the physical features.

d. Geological map of New Jersey to be compared with above to note relation of the topography upon the character of the rocks.

e. Map of New Jersey showing water basins, illustrating the complete division of a land into river basins.

f. Map of the United States colored to show the relief and physical features.

g. Topographic map of Now York and vicinity to show the relation of the position of the city to the physical features and history.

h. Topographic map of Rhode Island showing effects of glaciation upon drainage and the recent changes in position of land in reference to ocean.

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i. Four maps of the Coast and Geodetic Survey, showing different types of coasts upon the Atlantic seaboard.

Exhibited by the Teachers' College.

BOTANY.

I

In Charge of H. H. Rusby amd J. K. Small.

1. Topographical Maps of the site of the New York Botanical Garden, in the eastern end of Bronx Park, now being used in the locating of the driveways, buildings and plantations. Shown by permission of the Board of Managers.

2. Elements of Plant Anatomy. A text-book for the use of students. Exhibited by Prof. Emily L. Gregory, Ph. D. (Barnard College).

3. Studies in American Bryology. Exhibited by Elizabeth G. Britton (Torrey Botanical Club).
   1. The Genus Mnium. Illustrated by specimens and microscopic preparations.
   2. New and little-known Mexican Mosses, collected by C. G. Pringle and Jared G. Smith.

4. Studies in Leguminosae. Specimens illustrating new species of Rhynchosia Galactia and Meibomia from North America. Exhibited by Anna Murray Vail (Torrey Botanical Club).

5. Microscopic Preparations and Drawings illustrating a study of the Dorsiventrality of certain Climbing Organs. Exhibited by Martha R. Clarke (Barnard College).

   The cause of coiling in most tendril-climbers is believed to consist in a sensitiveness, usually limited to one side or flank of the coiling organ. In the most common instances there is an anatomical difference between the sensitive

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and non-sensitive sides. This study was undertaken to ascertain to what extent the anatomical characteristics correspond with the physiology.

6. Stems, Microscopic Preparations and Drawings Illustrating Studies of the Superficial Periderm of the Genus Euonymus. Exhibited by Harriet B. Elder (Barnard College).

The woody portions of stems of the different species of a genus are quite similar in anatomical characteristics, as are also, to a certain extent, the bark portions. The genus Euonymus presents a remarkable exception to this rule, as shown by the external appearance of the young branches and by sections.

7. Microscopic Preparations, Drawings and Wall Charts Illustrating a Comparative Study of the Development of the Superficial Periderm in the Genus Salix. Exhibited by Alexandrina Taylor (Barnard College).

In most text-books the work of Sanio is taken as authority on the development of superficial periderm. From the large number of species of the genus Salix he selected one as a type. The many variations from this type pointed to the possibility that by extending the study over a greater number of species than those studied by Sanio, one might be found which might more justly be called the type of the genus. This was the object of the study here illustrated.

8. Microscopic Preparations and Drawings Illustrating a Study of the Epidermal Cells of the Leaf of Euonymus Japonicus. Exhibited by Jane M. Atwater (Barnard College).

The connection of protoplasm of cells of the endosperm of certain seeds is considered a well-established fact, and many botanists claim that the majority of living cells are thus connected. The pores on the side walls of the epidermis of this leaf suggested the probability of such protoplasmic connection.

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9. Microscopic Preparations and Drawings Illustrating a Comparative Study of the Bark of Juglans cinerea at Different Seasons. Exhibited by Marion McEwen (Barnard College).

This study was undertaken in the interest of Research Committee C (investigating powdered drugs) of the Revision Committee of the United States Pharmacopæia, to discover characters in powdered Butternut bark, by which it could be determined whether it had been collected in the autumn as required.

10. Specimens of Seeds, Microscopic Preparations and Drawings Illustrating a Comparative Study of the Anatomy of the Strophanthus Seeds of Commerce. Exhibited by Prof. Smith Ely Jelliffe, M. D. (College of Pharmacy).

This study was undertaken under the same auspices as the last, for the purpose of discovering characters for distinguishing the different species and varieties of Strophanthus seeds in the powdered form. This drug is used in great emergencies, and some of the seeds of commerce are nearly or quite inert, while others are very powerful.

11. Specimens of Winter Twigs, Barks and Drawings Illustrating a Comparative Study of the Commercial Features of Viburnum Barks. Exhibited by Prof. Henry H. Rusby, M. D. (College of Pharmacy).

This study was undertaken under the same auspices as the preceding, in order to determine characters for the identification by collectors of the different species in the winter season, and also for identifying the barks in commerce, either entire or in powder.

12. Specimens of Plant and Fruit, Microscopic Preparations and Drawings, and Printed Report Illustrating a Study of the Anatomy of the Fruit of Serenoa serrulata (Saw-Palmetto). Exhibited by W. A. Bastedo, Ph. G. (College of Pharmacy).

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This fruit has been recommended as favorably modifying nutrition in the wasting of phthisis, and a collective study was made by Messrs. Rusby, Coblentz and Bastedo, in order to make it more perfectly known to the pharmaceutical and medical professions.

13. MATERIALS ILLUSTRATING A STUDY OF LICHENS. Exhibited by Albert Schneider, M. D. (Columbia University).
    1. Plates illustrating the mechanics, growth, and special morphology of lichens.
    2. A diagram showing the polyphyletic origin of lichens.
    3. The new system of lichens.
    4. A key to the families and genera.
    5. Specimens of lichens of historical interest.
    6. Microscopical preparations showing lichen-spores.
    7. Some papers on lichens.

14. SPECIMENS, MICROSCOPIC PREPARATIONS AND DRAWINGS, illustrating a Study of the Anatomy of Stipules. Exhibited by A. A. Tyler, A. M. (Columbia University).
    Investigation undertaken to ascertain the probable origin of these organs and their relationship to leaf-blades.

15. STUDIES IN AMERICAN CYPERACEÆ. Exhibited by Prof. N. L. Britton, Ph. D. (Columbia University).
    Specimens illustrating new species of Cyperus, Eleocharis and Rynchospora and other species new to the Flora of the United States.

16. THE NEW SPECIES OF NITALLA from Japan and North America. Exhibited by Prof. Timothy F. Allen, M. D. (Homeopathic Medical College).

17. THE NEW GENERA OF SAXIFRAGACEÆ, JEPSONIA AND SAXIFRAGOPSIS, illustrated by specimens and drawings.

18. NEW SPECIES OF PLANTS from the Southern United States, in the genera Smilax, Myrica, Quercus, Celtis, Polygonella, Rumex, Portulaca, Nymphæa, Clematis, Saxi-

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fraga, Ribes, Kneiffia, Œnothera, Nyssa, Cynoctonum, Gentiana, Scutellaria, Panicum and Sieglingia, illustrated by specimens.

19. OXALIS CORNICULATA and its North American Allies, illustrated by specimens.

Nos. 17–19 exhibited by John K. Small, Ph. D. (Columbia University).

20. NEW SPECIES of GRAMINEÆ in the genera Panicum, Erianthus and Chloris, illustrated by specimens.

21. NEW FLORIDA PLANTS in the genera Habenaria, Warea, Phaseolus, Glottidium, Cyrilla, Sida, Cornus, Monarda, Scoparia, Utricularia, Eupatorium, Lacinaria, Chrysopsis, Eriocarpum and Pluchea, illustrated by specimens.

Nos. 20 and 21 exhibited by George V. Nash (Columbia University).

22. SPECIMENS AND MICROSCOPIC PREPARATIONS illustrating studies on the moss genera CLIMACIUM and ENTODON. Exhibited by A. J. Grout (Columbia University).

23. NEW SPECIES AND VARIETIES OF LATHYRUS AND VICIA from North and Central America. Exhibited by Theodore G. White, A. M. (Columbia University).

24. SEVEN NEW SPECIES OF PLANTS FROM TEXAS, in the genera Samolus, Kuhnistera, Asclepias, Cressa, Verbena, Pentstemon and Houstonia.

These specimens partially represent the results of a revision of the genera.

25. STUDIES OF THE FLORA OF THE HAWAIIAN ISLANDS. Specimens illustrating numerous new and little-known species, collected during a visit to the Islands in 1895.

Nos. 24 and 25 exhibited by A. A. Heller (Torrey Botanical Club).

26. SPECIMENS AND PHOTOGRAPHS illustrating a monographic study of the genus Physalis in North America, now in publication in Memoirs of the Torrey Botanical Club.

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27. Studies in the Genus Potentilla. Specimens illustrating new and rare North American species.

Nos. 26 and 27 exhibited by Per Axel Rydberg, A. M. (Columbia University).

28. Two New Genera Collected by the Exhibitor in Bolivia. Rusbyella Rolfe, in the Orchidaceæ, and Rusbyanthus Gilg, in the Gentianaceæ.

29. Fifteen New Species of Rubiaceæ, collected in Bolivia by Miguel Bang.

Nos. 28 and 29 exhibited by Prof. H. H. Rusby, M. D. (College of Pharmacy.)

30. Critical Plants of the Local Flora. Exhibited by Eugene P. Bicknell (Torrey Botanical Club).

Specimens illustrating a special study of the local flora now in progress by the exhibitor. Illustrations from the genera Carex, Sisyrinchium, Hypericum and Helianthemum.

31. Additions to the Flora of New Jersey. Fifteen specimens. Exhibited by William Van Sickle (Torrey Botanical Club).

32. Additions to the Flora of Richmond County, New York.

These plants represent the species upon which was based the seventh appendix to the flora of Richmond County (Staten Island) New York, published by Arthur Hollick and N. L. Britton in 1879. The original catalogue contained about 1100 species. With the seven appendices the total now amounts to about 1400 species.

33. Leguminous Pods from the Yellow Gravel Sandstone at Bridgeton, New Jersey.

These pods represent the genera Mezoneurum and Lonchocarpus. They occur in sandstone of late tertiary or pleistocene age in the vicinity of Bridgeton, Cumberland County, New Jersey. The genus Mezoneurum is not

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known on the American continent. The genus Lonchocarpus has not been recorded north of Mexico. The pods apparently represent species which became extinct in recent geologic time, due to the climatic changes wrought by the advent of the ice age.

34. LIRIODENDRON LEAVES, Fossil and Living.

The living tulip tree (Liriodendron Tulipifera) is the sole representative in our modern flora of this genus, which in the past included a large number of species. By means of abnormal leaf forms and leaves from young shoots or seedlings, an attempt is here made to compare the evolution of the individual with the evolution of the genus in the past, as evidenced by the variation in leaf forms during successive geologic periods.

Nos. 32–34, exhibited by Arthur Hollick, Ph. B. (Columbia University).

35. COLORED LANTERN SLIDES OF FLOWERS. Exhibited by Cornelius Van Brunt (Torrey Botanical Club).

36. A DOUBLE FLOWERED FORM OF RUDBECKIA LACINIATA. Exhibited by E. S. Miller (Torrey Botanical Club).

Although the plant has been in cultivation for two hundred years, this is the first record of a double-flowered form.

38. ESSENTIALS OF VEGETABLE PHARMECOGNOSY, a text-book on structural botany, especially designed for Pharmaceutical and Medical Students. Exhibited by Prof. H. H. Rusby, M. D., and Prof. Smith Ely Jelliffe, M. D. (College of Pharmacy).

40. A COPY OF A TRANSLATION OF WESTERMAN'S *Compendium der Botanik*. Exhibited by Albert Schneider, M. D. (Columbia University).

41. VOLUMES OF THE BULLETIN AND MEMOIRS TORREY BOTANICAL CLUB FOR 1895. Exhibited by the Club.

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ZOÖLOGY.

J

IN CHARGE OF WILLIAM STRATFORD.

1. THE SEA LIFE OF THE PACIFIC SALMON, (with specimens of young).

   The young Oncorhynchus return annually with the adults to the mouths of rivers, and do not remain at sea until sexually mature, as usually stated.

2. LIVING SHIP WORM (Teredo navalis). A bivalve mollusc which destroys ships, wharves, &c., by boring tunnels in wood.

3. LIVING TUBE WORMS (Cistenides Gouldii) and others. Tube building worms.

4. FISHES new to this locality. Larimus and Elagatis, the runner.

   Numbers 1–4, exhibited by Tarleton H. Bean, New York Aquarium.

5. LARVAL stage of the Earthworm (Allolabophora fœtida). Exhibited by N. R. Harrington, Zoölogical Department, Columbia University.

6. EGGS OF THALASSERNA (A marine worm). Showing recent discoveries in Cytology.

7. I. The Origin of the Centrosome of the second polar spindle from that of the first.

   II. The Origin of the Centrosome of the second cleavage spindle from that of the first.

   Exhibited by Bradley B. Griffin, Zoölogical Department, Columbia University.

8. Nuclear Changes in Noctiluca (a Protozoan).

   Exhibited by G. N. Calkins, Zoölogical Department, Columbia University.

9. Studies in the Excretory System of Leeches.

   I. An Excretory Cell with its intra-cellular musculature.

   II. An Excretory funnel, showing structure of cells and cilia.

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Exhibited by Arnold Graf, Zoölogical Department, Columbia University.

10. Preparations illustrating Karyokinetic cell division in the Egg of an Annelid (Nereis).

Exhibited by E. B. Wilson, Zoölogical Department, Columbia University.

11. Eggs and Larvæ of Amia calva (the Mud-fish or Bow-fin).

Exhibited by Bashford Dean, Zoölogical Department. Columbia University.

12. MOUNTED ASIATIC ELEPHANT "Tip," illustrating recent improvements in taxidermy.

13. GREENLAND WALRUS, female and young calf, collected by Prof. L. L. Dyche, on the Peary Relief Expedition of 1895.

14. SHIN and SKULL of the fish-eating Rodent, Ichthyomys Stolzmanni Thomas, from Peru—the second known specimen.

15. Specimens of the SNOWFLAKE, Plectrophenax nivalis, illustrating change of color from the winter to the breeding dress by the shedding of the tips of the feathers.

16. Specimens of the SANDERLING AND OTHER BIRDS, illustrating the change of color by moulting in species alleged to acquire the breeding plumage by change of color in the feathers without moulting.

Nos. 14–18, exhibited by Department of Mammalogy and Ornithology of American Museum of Natural History.

BACTERIOLOGY.

K

IN CHARGE OF F. M. CHEESMAN.

1. CULTURE OF BACILLUS. No. 41. Exhibited by Prof. H. W. Conn, Wesleyan University.

Morphological preparations of Bacillus, No. 41. This bacillus, obtained originally from a specimen of milk

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from Uruguay has been found to possess a marked power of ripening cream for butter making.

Experiments in various dairies have shown that the use of this bacillus for the production of flavor in butter is feasible and that a somewhat enhanced keeping property is given to the butter by the use of this culture.

ANATOMY.

L

IN CHARGE OF GEORGE S. HUNTINGTON.

1. RECENT OBSERVATIONS IN HUMAN AND COMPARATIVE MYOLOGY.
   - *a.* New and rare variations of the Pectoral Group in Man.
   - *b.* Morphology of the Sternalis Muscle; Relation of the muscle to the Structure of the Pectorales in Mammalia.

   Human M. Sternalis

   Pectoral muscles of Hydrochœrus capybara.
   " Enthizan dorsatus.
   " Dasypus sexcinctus.
   " Tatusia peba.
   " Manis macrura.
   " Viverra civetta.
   " Hapale jacchus.
   " Macacus nemestrinus.
   " Didelphis virginiana.

2. Anatomy of the Pectoral muscles in *Felis leo*. Exhibited by Mr. Line.

3. MYOLOGY OF THE SHOULDER GIRDLE OF *Lagothrix humboldtii*. Exhibited by Mr. Lee.

4. MYOLOGY OF THE ANTERIOR EXTREMITY OF *Lemur bruneus*.

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PALEONTOLOGY.

M

In Charge of J. L. Wortman.

1. Series of Skulls of Uintatheres, showing their development in time. From the Eocene of the Bridger Basin, Wyoming. Collected by Messrs. Wortman and Peterson, between 1893 and 1895. Also, from the Cope collection recently acquired by the Museum.
2. Two Skulls of a new and remarkable form of Titanotherium. From the Miocene of Dakota.
3. Skeleton of Hyrachyus Agrarius, one of the primitive Rhinoceroses. From the Eocene of the Bridger Basin, Wyoming. Mounted by Adam Herman.
4. Skull of an undescribed genus of ancient carnivores. From the Eocene of the Uinta Basin, Utah. Collected by Messrs. Wortman and Peterson, in 1895.
5. Teeth and Forefoot of the earliest ancestor of the Dog family. From the Eocene of the Uinta Basin, Utah. Discovered by Mr. Peterson in 1895.
6. Skull of a Monkey, Hyopsodus, Leidy. From the Eocene of the Washakie Basin, Wyoming. Discovered by Dr. Wortman in 1895.
7. Series of original restorations of extinct North American Mammals. Drawn by Charles R. Knight, under the direction of Prof. H. F. Osborn and Dr. J. L. Wortman.

   Nos. 1–7 exhibited by the Department of Vertebrate Paleontology Amer. Mus. Nat. Hist.
8. Eoördovician. Invertebrates from the Calciferous and Chazy formations of the Lake Champlain region. Collection of 1895. Exhibited by Gilbert van Ingen.

   Special features:

   a. *Ophileta* from Calciferous of Beekmantown, N.Y.

   b. *Trilobites* from Calciferous of Fort Cassin, Vt.

   c. Chazy fossils from Plattsburgh and Chazy, N. Y., and Highgate Springs and Basin Harbor, Vt.

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GEOLOGIC TIME-SCALE (lower portion).

Names italicised indicate epochs, representatives of the fossil life of which are shown in exhibits Nos. 8, 9, 10 and 11.

	Neosilurian.	Lower Helderberg.
Silurian.	Eosilurian.	*Niagara.** *Clinton.* Medina.
Ordovician.	Neoördovician.	Hudson. *Utica.* *Trenton.* *Black River.* *Birdseye.*
	Eoördovician.	*Upper Chazy.* *Middle Chazy.* *Lower Chazy.* *Upper Calciferous.* Middle Calciferous. Lower Calciferous.
Cambrian.	Neocambrian.	Potsdam.

* Including Guelph and Salina.

9. NEOÖRDOVICIAN. Invertebrates from the Black River, Trenton and Utica formations of the Lake Champlain region. Collection of 1895. Exhibited by Theodore G. White.

Special features:

a. Fossils indicative of particular zones of the Black River limestone from its lower to its upper limits, as:

1. *Leperditia* from base of the formation at Button Bay Island, Vt., and Chazy, N. Y.

2. *Strophomena filitexta* from Button Bay Island, Vt.

3. *Stromatocerium* and *Columnaria* from the above localities, forming at the former locality a coral reef band two feet in thickness.

4. *Maclurea*, a peculiar Black River species from Chazy, N. Y.

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5. *Parastrophia*, from a restricted zone at the top of the Black River formation at Larabee's Pt., Vt., and also from 78 miles to the northward, at Highgate Springs, Vt.

b. Trenton—Selection of various representative fossils from the entire length of the lake shores, including some peculiar forms from Cumberland Head, near Plattsburgh, N. Y.

c. Utica—*Graptolites* from Larrabees Pt., Vt., and Ticonderoga, N. Y. *Lingula* and *Orthis* from Vergennes, Vt. *Triarthrus* and *Graptolites* from Isle la Motte, Vt.

10. NEOÖRDOVICIAN—Fossils illustrating the sequence of the later Ordovician faunulæ at Trenton Falls, N. Y. Collections of 1895. Exhibited by Theodore G. White.

Special features:

a. Calciferous dolomite, dove limestone and fossils of the Black River limestone, from near Poland, New York.

b. Fossils from the original section from which the Trenton formation was named, arranged in zones as determined by a recent stratigraphic study by the exhibitor.

c. Utica *graptolites*, *trilobites* and *orthoceratites* from Nine Mile Creek, East Trenton, New York.

11. EOSILURIAN.—Fossils from the Clinton and Niagara formations of Rochester, New York. Exhibited by Gilbert van Ingen.

Special features:

a. *Graptolites*, *Brachiopods* and *Pteropods* from the red and green shales of the Clinton series.

b. Various fossils from the Niagara shale.

Note.—Photographic views and maps illustrating the localities from which were obtained the specimens of exhibits Nos. 8, 9, 10 and 11, will be found in the section of Geology.

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12. A STIGMARIA FRAGMENT of exceptional size from Indian Territory. Exhibited by J. J. Stevenson.

13. MOLLUSCA from the Asphalt Beds of Indian Territory. Exhibited by J. J. Stevenson.

ETHNOLOGY AND ARCHÆOLOGY.

N

IN CHARGE OF FRANZ BOAS AND M. H. SEVILLE.

1. THE ANIMAL FORM IN THE ART OF ANCIENT PERU. From the collections of the American Museum of Natural History. Exhibited by Mr. Harlan I. Smith; collected by Mr. A. F. Bandelier.

   Representations of animal forms of pottery, painting, weaving, gold, stone and wood in the art of ancient Peru.

2. PORTRAIT HEADS in Pottery of Ancient Peru. From the collections of the American Museum of Natural History. Exhibited by Mr. Harlan I. Smith; collected by Mr. A. F. Bandelier.

3. PATHOLOGICAL SPECIMENS from an ancient burial ground in Kentucky. From the collections of the American Museum of Natural History. Exhibited and collected by Mr. Harlan I. Smith.

   These specimens were excavated on the Fox Estate, May's Lick, Mason County, Ky., on an area of about forty acres. Part of them were found in stone graves, others in mounds, but both groups probably belong to the same people. Both sexes were equally subject to inflammation and suppuration of the bones, 19 among 55 adults (35%) being affected with it. The disease was rarely present in children and youths.

4. BURIAL CUSTOMS OF A PREHISTORIC PEOPLE OF UTAH. Collected and presented to the American Museum of Natural History by Messrs. B. T. B. and F. B. Hyde; exhibited by Messrs. B. T. B. Hyde and George H. Pepper.

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This collection represents burial under baskets as practiced by a prehistoric people of Utah and was discovered by Richard Wetherill, of the Hyde Exploring Expedition during the winter of 1893–94.

5. PHOTOGRAPHS OF PICTOGRAPHS FROM UTAH. Collected and exhibited by Mr. B. T. B. Hyde.

6. TYPICAL COLLECTION OF MATERIAL FOUND IN AN INDIAN BURIAL PLACE AT TOTTENVILLE, S. I. From the collections of the American Museum of Natural History. Exhibited by Mr. George H. Pepper; collected by Messrs. George H. Pepper and M. H. Saville.

7. COLLECTION OF ANCIENT PUEBLO SKULLS. Exhibited and collected by Dr. Walter Fewkes, Washington, D. C.

8. DIAGRAMS SHOWING THE GROWTH OF CHILDREN IN VARIOUS CITIES OF AMERICA. Exhibited by Dr. G. M. West.

9. DIAGRAM SHOWING THE DIFFERENCE IN THE RATE OF GROWTH OF FIRST-BORN AND LATER-BORN CHILDREN. Exhibited by Mr. Franz Boas.

The diagram shows that first-born children develop physically better than later-born children. They are both taller and heavier than the latter.

10. ANTHROPOMETRICAL CHARTS. Designed and exhibited by Prof. W. Z. Ripley.

11. PHONOGRAPHIC RECORDS OF INDIAN SONGS. Exhibited by Mr. Franz Boas.

Songs of Kwakiutl Indians of Vancouver Island, recorded in 1893.

12. THE BEAVER IN THE ART OF THE INDIANS OF BRITISH COLUMBIA. Exhibit of the Department of Anthropology of the American Museum of Natural History.

Showing the conventional forms in which the beaver is represented in carvings, etchings and paintings of the Indians of British Columbia.

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13. Artificial Deformations of the Human Skull. Exhibited by Mr. Franz Boas.

The distribution of the practice of artificial deformation of the skull and specimens of deformations, together with photographs of living individuals with deformed heads.

14. Busts of Eskimo Man and Woman. Sculptured from life and exhibited by Mr. Caspar Mayer.

From the collections of the American Museum of Natural History.

15. Ten Albums of Photographs, illustrating the recent explorations of the ancient ruins of Copan, Honduras, under the direction of the Peabody Museum, Prof. F. W. Putnam, Curator of the Museum. Exhibited by Prof. F. W. Putnam.

16. Arrow Games in Asia and America. From the collections of the Museum of Archæology, University of Pennsylvania. Exhibited by Mr. Stewart Culin.

Illustration of the origin of playing cards and chess in the arrow, and hypothetical development of seal cylinder, Chinese coin, the folding fan.

EXPERIMENTAL PSYCHOLOGY.

O

In Charge of J. McKeen Cattell.

1. Pendulum Chronoscope; Electrical Color Wheel with Speed Indicator; Multiple Key; Clock Contact. Exhibited by Dr. E. W. Scripture, Yale University.

2. Pendulum Chronoscope. Exhibited by Prof. Charles B. Bliss, New York University.

3. Apparatus for Determining Photometric Differences by the time of Perception. Exhibited by Prof. J. McKeen Cattell, Columbia University.

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VOL. XV.

1895-1896.

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Late LYCEUM OF NATURAL HISTORY.

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